UNIVERSITY
OF MICHIGAN
JUN 24 1953
PUBLIC HEALTH
LIBRARY

AMERICAN

Industrial Hygiene

ASSOCIATION

Quarterly

VOLUME 14, NUMBER 2
JUNE, 1953

What can be done to stop —

AIR POLLUTION?

The answer is "plenty"! Sure there are problems yet to be solved—and new ones will be created as industry develops and expands. But the fact remains that *dust*, one of the major factors in most air pollution problems, has been and can be controlled effectively.

The American Air Filter Company first tackled industrial air pollution over 20 years ago. Since then, AAF engineers have literally "lived" with industry's many and varied dust problems. Result — ROTO-CLONE—the world's most complete line of dust control equipment.

Today, over 20,000 ROTO-CLONE units are helping industry to forestall court injunctions, citizens committees and irate housewives by removing that major irritant —dust. With dust under control, the other problems of air pollution often disappear or take on less importance.

Start now by appointing your local AAF representative as a "committee of one" to check your present dust sources and recommend effective means of control. Call him, today, or write us direct. Remember—"big air pollution problems from little dust sources grow".

You Can Expect the Best From

American Air Filter
COMPANY, INC.

AAF

253 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

AMERICAN
INDUSTRIAL HYGIENE
ASSOCIATION
Quarterly

Volume 14 JUNE, 1953 Number 2

A UNIQUE AMERICAN INSTITUTION
The Cummings Memorial Lecture 89
Warren A. Cook

NEPHELOMETRIC DETERMINATION OF NITRITE SOLUTIONS 98
William H. Hill and Theodore Hatch

FLY ASH COLLECTION IN INDUSTRIAL EXPERIENCE 103
B. S. Norling

NOTES ON DERTERMINATION OF LEAD BY DITHIZONE METHOD
I. Effects of Impurities in Cyanide 109
Hervey B. Elkins, Ph.D.

II. Interference from Bismuth and Tin 111
Hervey B. Elkins, Ph.D., and Benjamin P. W. Ruotolo, M.D.

PREPARATION OF KNOWN CONCENTRATIONS OF GASES AND VAPORS IN AIR 113
Alfred N. Setterlind

AIR SAMPLING INSTRUMENTATION AND METHODS
A Critical Examination 121
William T. Ingram and Lawrence F. Dieringer

CONTAMINANT CHARACTERISTICS ENCOUNTERED IN LOCAL EXHAUST SYSTEMS—A Graphic Presentation 133
James R. Kayse

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION
Fourteenth Annual Meeting 138
President's Page 139
News of the Local Sections 141
Officers and Committees 143

AMERICAN INDUSTRIAL HYGIENE ASSOCIATION QUARTERLY, published by the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION in March, June, September, and December. WILLIAM T. MCCORMICK, Editor; HOWARD N. SCHULZ, Associate Editor; HERBERT T. WALWORTH, Advisory Editor; JOHN J. FERRY, Advertising Editor; LLOYD E. GORDON, Circulation Editor; A. D. CLOUD, Publisher; DORIS FLOURNOY, Editorial Assistant. Publication, and Editorial Offices, 605 North Michigan Avenue, Chicago 11, Illinois. Subscription $2.00 per year in the United States; $2.50 per year in Canada; $3.00 per year in other countries. Single copies 75 cents. Copyright, 1953, the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION. Entered as second class matter May 3, 1948 at the post office at Sheboygan, Wis., under the Act of March 3, 1879.

Protect Your Workers' Hearing

avoid possible lawsuits by using

FLENTS*

anti-noise EAR STOPPLES

noise is HIS enemy

Prominent Scientists Say:

". . . to keep noise out effectively a plug must completely close the ear canal with an air-tight seal."

". . . there can be no doubt about the primary benefit of ear plugs in noisy locations, provided the workers wear them, and provided further that they completely occlude the ear canal."

FLENTS ANTI-NOISE EAR STOPPLES fit any ear canal, no special sizes to bother with. Flents have been used for years by many foremost manufacturers and government agencies.

SAMPLES ON REQUEST

FLENTS PRODUCTS CO., INC., Dept. H-63, 103 Park Avenue, New York 17

*Reg. U.S. Pat. Office

A Unique American Institution

The Cummings Memorial Lecture

WARREN A. COOK, Director
Division of Industrial Hygiene and Engineering Research
Zurich-American Insurance Companies, Chicago

IN HIS LATEST BOOK, James Bryant Conant postulates a number of theses on the significance of modern science to modern man. An exemplification of a portion of his theories is to be found in the development of the unique American institution which is the subject of this Cummings lecture.

Warren A. Cook

The publisher of Conant's absorbing book, which to me was not altogether unprofound, held forth the promise on the jacket that the author's ideas were couched in "simple and exciting terms." To those of us who have participated in the development of this institution, its course has had exciting as well as rewarding aspects.

I trust that a recounting of this development will be not without interest both to such of you as have followed its progress, as well as to others who may not be familiar with the institution of which I am to speak. In considering the enthusiasm of the industrial hygienist for this field, I hope none of you will be as perplexed as a certain well-behaved youngster was when he found his two maiden aunts seated motionless on either side of a chess table. He stood silently waiting for them to divert their intent gaze from the chessmen and speak to him. Minutes passed, until finally one of them leaned back, sighed, and exclaimed, "How thrilling!"

Before relating the more thrilling phases of this unique American institution, perhaps I should let you know exactly what it is and why it is unique.

Throughout the world, science has been assuming increasing importance in our economic and business life. But only in the United States has the branch of science in which we are most interested become an integral part of the major branch of business concerning us. The branch of science to which I refer is industrial hygiene; the branch of business, casualty insurance.

Why is it, you may ask, that an industrial hygiene division in the casualty insurance business is unique to America? We would certainly resent any implication that it has anything to do with the schoolboy's explanation of the derivation of the word, unique, as coming from the Latin *unus*, one, and *equus*, horse. This is no one-horse institution!

The actual answer is that only in the United States is insurance for workmen's compensation extended by private companies with the single exception of Belgium. In our country, private enterprise is insured by private enterprise in most of the states. And where coverage is extended for workmen's compensation, there is a normal obligation that the insurer extend its aid in preventing injury to the worker.

As stated so aptly by Albert Wurts Whitney, "Not only . . . does insurance draw the fangs of misfortune by binding society together to bear each others burdens, but it contains within itself an even

Presented at the Fourteenth Annual Meeting, AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, April 23, 1953, Los Angeles.

more patent virtue—the power to prevent misfortune itself as well as misfortune's effects. This secondary effect of prevention is every bit as important as its primary effect of distribution."

In accepting this responsibility for prevention of injury, the insurance industry has built extensive conservation departments for which it has expended millions of dollars. The greater part of the activity, to be sure, has been in the field of accident prevention since traumatic injuries are much more frequent and cause much more lost time than occupational diseases. Measured by compensation paid, occupational disease claims amount to only about 1½% of the total. However, this is not a measure of the relative concern of the insurance company or of the employer. When an accident occurs, it is unfortunate, but when an occupational disease occurs, the apprehension both of the insurance carrier and of the employer is of much greater moment than is measured by the cost of the occupational disease claim. And there is ample reason for this as we shall see.

Organization of industrial hygiene within the casualty insurance company follows a pattern but varies in the extent to which certain elements are included. All of the casualty companies have safety engineers who visit industrial plants and work with the industrial concern for control of health hazards as well as prevention of accidents with the latter constituting the major portion of their function. Observations of plant conditions through such inspections has brought to the attention of industry and the casualty companies many facts on industrial health hazards. Where these hazards appeared to be excessive, recommendations for their control have been based on such observed facts. Much effective work on improving environmental conditions has resulted from these inspections.

This method of attack on a problem is what Conant terms an empirical approach. He uses the term empiricism to connote the concept of observation of facts rather than the principles which explain them; the trial-and-error method of experience, rather than that of developing a theory whereby the outcome may be predicted. He points out that great progress has been made in the practical arts by well-ordered empirical procedures. In the field of industrial hygiene we are aware of a multitude of situations where just such empirical methods have accomplished the desired results.

But prior to 25 or 30 years ago when for the most part empirical methods only were being applied to industrial hygiene problems, unexplained cases continued to occur.

In a plant handling lead compounds, for example, the great emphasis formerly was placed only on eating in separate lunch rooms, washing the hands before meals, and similar hygienic measures designed largely to reduce the amount of lead ingested. Through the persistent influence of the inspector these measures were often meticulously observed only to be followed by continuing cases of lead poisoning. Physicians made frequent physical examinations including blood samples for stippled cells. The workers with positive findings were transferred to locations in the plant where no lead exposure existed until there were no more such jobs available and circulation of workers between lead and nonlead jobs at frequent intervals became the order of the day to the despair of the plant managements. And still cases of lead poisoning continued.

INTRODUCTION of modern scientific methods has explained the reason for these lead poisoning cases and has shown the way to avoid them. With the best of personal hygiene practices, it was found through research that presence of excessive amounts of lead in the air resulted in absorption of enough lead through the lungs to cause symptoms of lead poisoning.

Science went further and extended the qualitative information of absorption of lead from the air to the quantitative concept which is the basis of modern scientific industrial hygiene. It is not enough to know that there is lead dust or fume in the air—or that lead is being absorbed by the body of the worker; it is essential to know how much and to relate this amount to that required to cause lead poisoning.

The value of this quantitative concept in the scientific method of approach is well illustrated by William T. Jones of Pomona College in his "History of Western Philosophy." In discussing the practical advan-

tages of the quantitative over the qualitative, he presents an example which all of us can appreciate. He points out that "if we want to buy a rug for a room, we stand a better chance not to be disappointed if we go to the shop with quantitative information obtained by measurement than if we carry only qualitative information. It is much better to be able to tell the salesman that the rug is for a room four yards by five yards rather than merely to say: 'Well, it is really quite a nice big room.'"

The emphasis on the quantitative may seem too self-evident to discuss, but it has been a long time becoming accepted. However, the advantages of such an approach have not yet seeped through to many areas and vigorous promotion appears still to be needed for acceptance of quantitative methods. Often only after acceptance of such a concept does its advantage become self-evident.

The transition from the empirical to the scientific takes us from the control of health hazards by inspection—still an important factor—to their control by the modern industrial hygiene approach. This calls for supplementing the work of the safety engineering personnel with a staff having chemical, physical, or engineering background, special training in industrial hygiene, and implemented with adequate field sampling apparatus together with an industrial hygiene laboratory—in some cases a main laboratory at the head office and branch laboratories at certain industrial centers. The field equipment is used to some extent by the safety engineering personnel, but for the most part by the specially trained industrial hygiene staff.

The functions of the industrial hygiene division of the casualty insurance company must of necessity include a number of elements which other industrial hygiene units need not consider. But it is to be noted that the major function of the insurance company unit is essentially the same as that of units connected with other organizations, namely to keep health hazards sufficiently well controlled that cases of occupational diseases do not occur.

When the casualty company is requested to extend compensation coverage to an industrial concern which involves an occupational disease exposure of some moment, the industrial hygienist is called upon first to evaluate the extent of the hazard in terms of probable occupational disease losses. This estimate is desired not only for the normal policy period of the ensuing year, but also for a more extended period since insurance companies ordinarily wish to contemplate a continuity of coverage year after year. This evaluation may be on the basis of a report by the safety engineer in the area. If, for example, the industrial concern which the agent wishes the casualty company to insure operates a quarry with a crusher house, samples of air-floated, settled dust might be requested by the industrial hygienist for free-silica determination. If these samples show appreciable percentage of quartz, chest x-rays might be required so that the insurance company could be adequately informed on the liabilities it was assuming—and in most states, the insurer is liable for the entire amount of all occupational disease claims filed after the policy is in effect.

LET US CONSIDER what this might amount to in a possible situation. The premium received by the insurance company would be based on a rate dependent on the average compensation payments over recent years for the pertinent industrial classification. This rate would be expressed as the amount in dollars and cents per hundred dollars of payroll necessary to meet such payments plus a loading for costs of doing business. More graphically, the average occupational disease payments for the classification we are considering might be represented as one $12,000 silicosis case per hundred employes every five years.

The premium would presumably have been adequate if such silicosis claims occurred uniformly in this hypothetical plant of 100 employes once every five years. But the insurance company would be faced with losses substantially greater than the premium in the event that three or four high award silicosis claims were filed the first year of coverage.

This would result in payments of $36,000 or $48,000 (assuming the $12,000 as the average and not including costs incidental to handling claims) for which the premium income would be but $2,400 (assuming an occupational disease premium based on the

one such silicosis case every five years, and again not including the increment for incidental costs). This considerable loss to the insurance company could readily occur if attention were not given to the scientific data of the free-silica analysis and the interpretations of the x-ray films. All that would be necessary would be for 10 or a dozen of the employees to have developed silicosis over the preceding years and active tuberculosis to have infected three or four of these with resulting total disability during the first year of coverage.

And this is not the only occupational disease pitfall that the insurance company must avoid. Consider an actual situation where a casualty company was insuring a concern engaged in manufacturing asbestos products. This concern purchased an additional plant and in the ordinary course of business the casualty company included it in its compensation policy. Premium in the amount of some $6,000 for the year's occupational disease coverage was collected and everyone was happy. But not for long. The large concern decided to transfer operations from the newly purchased plant to another location. With the closing of the plant, the employees were thrown out of work, only a few accepting the offer of management to move to the new location. An enterprising attorney—forgive me if the epithet constitutes a redundancy—accepted as liability cases those of the idled workers whose chest x-rays demonstrated asbestosis. Compensation awards were granted for a total of $144,000 with an additional $19,000 for medical. And this was a number of years ago before claims had reached the present-day peaks such as the recent much publicized case where a group of ship-yard workers brought liability suits for loss of hearing due to noise totaling five million dollars.

Thus, it is obviously imperative that the insurance company industrial hygienist have adequate information before him when he expresses his opinion to the underwriters of his company that no more than normal losses due to occupational disease are to be expected.

Once the compensation coverage has been extended, it is up to the industrial hygienist to see to it that conditions are such that occupational disease cases do not occur. In fact he must go even further and reduce the possibilities of unjustified claims being presented. And all this while maintaining the good will of the insured concern.

The methods of control of occupational disease hazards followed by the insurance company industrial hygiene divisions are those in common practice by industrial hygienists throughout the country: substitution of less injurious materials; enclosure; ventilation; segregation; introduction of personal protective equipment with education regarding its use; evaluation of the exposure by air analyses; examination of the urine for the toxic material or conjugation products; checking occupied areas for magnitude of radiation, and to a lesser but increasing extent, determining noise levels both over-all and by frequency bands.

Now what, you may ask, is so exciting about the insurance company industrial hygiene division doing the usual things in the usual way? Let me carry you through a sequence of events in an actual case and leave to you the opinion of whether the workings of this unique American institution may have their thrilling aspects.

THE INCIDENT began on a July day when an agent referred the application for compensation insurance of a cable and wire insulating concern to the casualty company. Coverage was extended and an inspection made in accordance with routine procedures. The report showed that benzol was used as the solvent for the asphaltic material in which the asbestos insulation was impregnated and also that, some weeks before the expiration of the previous policy, a worker had become disabled due to benzol poisoning. A representative of the chemical unit of the insurance company was dispatched to the plant where it was obvious to him that only through air analyses could it be determined whether the recently installed ventilated enclosures were adequate to maintain benzol exposures within safe levels. The plant management was not only cooperative but was eager to take adequate measures to control the hazard. Authorization was obtained by the industrial hygienist to assemble the necessary air-sampling equipment and special chemical apparatus for what was to be the first industrial hygiene approach along modern

scientific lines to an occupational disease problem by a casualty insurance company—this being some twenty-seven years ago. Fortunately data was available even then for interpretation of results as LEONARD GREENBURG, last year's Cummings lecturer, had just published a report on benzol poisoning under the joint auspices of the National Safety Council and the United States Public Health Service including results of animal experimentation conducted at Yale University Medical School with the recommendation that concentrations in air be kept below 100 parts per million by volume for prolonged exposures and that periodic blood examination including differential white cell count be made.

The air analyses were conducted under no little pressure on the part of the underwriters as the decision of whether compensation coverage was to be continued or cancelled was to depend on the results. The literature showed the best air analysis method was collection of the benzol from the air of the plant by drawing the air through a tube containing mixed nitric and fuming sulfuric acids to form dinitrobenzene and then taking these samples to the laboratory for completion of the analysis with a standardized reducing reagent. This procedure did not seem difficult and the underwriters were promised early results. However, just before starting the analyses, correspondence was received from DR. HENRY FIELD SMYTH, SR., of the University of Pennslyvania, stating that titanous trichloride was preferable to the stannous chloride given in the published method but, as the titanous trichloride oxidized readily in the air, its standardized solution had to be kept under an atmosphere of hydrogen gas and the actual titration had to be conducted in an Erlenmeyer flask from which air was excluded by a stream of carbon dioxide.

This added complications. The underwriters were becoming impatient, vociferously so. Perhaps they had better cancel the policy anyway. But having gone this far, with the cooperative attitude of the insured concern, with the probability that the neatly designed and well fabricated ventilation had controlled the hazards, perhaps a few more days could be allowed to obtain the results. Reluctant acquiescence to this plea was followed by delivery of added equipment and the new reagent. It was well into the evening before the closed system of hydrogen gas from a Kipp generator to the titanous trichloride solution bottle and to the top of the burette was set up, the solution standardized and a trial run with a known amount of benzol successfully completed. And it was well along in the wee small hours that the analyses of the plant air samples were completed.

As I calculated the results (for I must confess this was a personal experience) all by myself in that laboratory which had been set up in a penthouse on top of the office building, with the waning moon visible through the window, I can well recall how tense I was—willing that the conditions be found satisfactory but apprehensive that they might not be. Almost like coming to the last pages of a mystery story long after bed-time and willing the hero to arrive in time to save the heroine from the clutches of the villain. But no "willing" could change the final figures of the analyses. The results showed that the concentration of benzol vapor in certain areas was still sufficiently excessive to cause poisoning. I felt as dispirited as the fisherman at the close of Hemingway's "The Old Man and the Sea." I was beaten and went home to bed.

The next morning the results had to be reported but a review of them pointed a finger at the offending operation. The impregnating pots were adequately ventilated, exposures were low in their vicinity, but enough benzol was still evaporating from the finished cable as it was being wound on the reels to cause the excessive concentrations found in the end of the room where they were located. We were sure these also could be satisfactorily enclosed and ventilated, and that the management of this concern on being apprised of results of the analyses would lose no time in completing the job.

The underwriters felt that they could continue coverage a couple of weeks longer on the probability that the hazard would be properly controlled. It was true that blood tests had shown a number of workers to be affected by the past benzol exposures but these men could be kept away from the area where benzol was in use. Coverage

was being continued largely on the assurance of the person who would today be called the industrial hygienist. But that person almost wished that the decision to continue coverage had been otherwise for what if one of the workers with impaired blood producing capacity as demonstrated by the differential white cell count should take a turn for the worse even though no longer exposed to the benzol vapor. It was true that the life of one of these workers was of inestimably greater importance than the decision of whether or not an insurance company continued occupational disease coverage, but to the industrial hygienist the two considerations were wrapped up together and were part and parcel of a new method of assuring a safe operating condition for the worker while permitting continuation of compensation coverage with greatly reduced probability of serious loss.

The added ventilated enclosure was installed, further air analyses demonstrated benzol vapor concentrations to be within the maximum allowable concentration throughout the plant and periodic blood tests showed that blood counts were all returning to normal. The industrial concern was pleased, the agent was jubilant, the insurance company was relieved, and the industrial hygienist was gratified.

It looked like a happy ending.

Then came November, usually the month of Thanksgiving, but in this case it brought the shocking news that the man who had been ill just prior to extension of coverage, then had felt well enough to return to work for a few days in August, had died of aplastic anemia—a fatal case of benzol poisoning!

Again the industrial hygienist felt the despair of Hemingway's fisherman. He had achieved his purpose but something beyond his control had taken the triumph away. There was the consolation that by the time he entered the picture it was too late to save the man's life, it was true; but his recommendation regarding coverage had through an unfortunate slip permitted a substantial loss to his company. However, this true story did come to a happy ending after all. The insurance company paid its loss but retained its conviction that the occupational disease exposure was under control and continued coverage. And it is a matter of record that there has been no further case of benzol poisoning at that plant over all these intervening years.

The elements of this situation thus involved the application of scientific methods of modern industrial hygiene to a difficult problem where men's lives were entwined with the results of air analyses, the success of engineering control, with a profitable industrial process and extension of compensation insurance.

THIS CASE was cited as the first instance of modern industrial hygiene procedures by a casualty insurance company. It is to be noted that a life insurance company in connection with its group coverages had an industrial hygiene division, capably staffed, and conducting air analyses and other phases of modern industrial hygiene as early as 1925.

Before concluding with a review of some of the accomplishments of the industrial hygiene divisions of the insurance companies, let us consider the reasons why occupational diseases tend to cause greater apprehension than traumatic injuries even though the compensation costs are far less.

From the viewpoint of the manufacturer, one case of occupational disease or even a condition which may be thought to be causing injury to health has a deleterious effect on industrial relations. This may be so severe that it becomes difficult to induce men to work at an operation under suspicion. Even when no actual case of occupational disease occurs, fear that injury may develop can threaten the operation of a whole plant. During the early days of the war, workers at a vital synthetic rubber production plant were threatening just such a walk-out until industrial hygienists, one from a university and one from an insurance company, were called in and after a thorough survey gave assurance that everything possible was being done to avoid excessive exposures. And there are instances of strikes based on the issue of unhealthful working conditions.

There are a number of considerations regarding occupational disease which deeply concern the casualty company. Among these is the situation that one case of occupational disease may be the forerunner of a succession of such cases. Certainly if the

condition which injures the health of the employee is not recognized nor properly brought under control, other workers subjected to the exposure or new workers replacing those who have developed disabling symptoms may be expected to become disabled also. Unhealthful working conditions affect the traumatic injury experience in two ways. Increased labor turn-over which is often incident to such conditions results in higher accident frequency rates as does the lowered alertness of workers excessively exposed to many of the health hazards such as narcotic solvent vapors.

Furthermore, it has been the history of occupational disease compensation that a considerable number of workers may be affected by a health hazard but have done no more than complain about it. Then suddenly and without warning one of the group presents an occupational disease claim and compensation is awarded. This may be followed by claims from others of the group until it has spread from plant to plant within an industry. Where large recoveries are possible as in common law suits, the probability of employers liability losses reaching the upper limits of the policy is appreciable.

In event of a traumatic injury, such as a broken leg, the duration and extent of disability is usually apparent. Even if there may be some quibble as to the percent of total partial disability, there is seldom any great disparity of ideas between the injured and the adjuster. But where a man has chronic lead poisoning or roentgenologically demonstrated silicosis, who can tell whether or not a man is malingering or is actually too weak to work?

In the case of new health hazards, the occupational disease rate, based as it is on past experience, often includes no increment to cover losses from such an unanticipated cause. This was true of industrial classifications involving exposure to radium in the twenties, silicosis in the thirties, and exposure to beryllium in the forties. In the fifties it appears that noise will be the cause of increasing occupational disease claims, but it is very possible that an adequate rating structure may be set up to take care of such losses.

A major threat of greatly excessive losses due to occupational disease is that resulting from unemployment following business depression. The tremendous losses of the casualty companies from silicosis claims during the depression of the early thirties was due to a combination of unemployment, lack of properly discriminating diagnosis, and the fact that there were no records of air analyses to show whether or not workers had been breathing injurious amounts of dust, as well as failure to make proper distinction between economic disability and physiologic disability. Even today it is of course often difficult to distinguish between the two.

There is a continuing trend to broaden occupational disease compensation, to include more and more debilities as being due to the occupation and consequently compensable. Though this is not the place to discuss the pros and cons of this trend, it places an increasing responsibility on the shoulders of the industrial hygiene division to anticipate and forestall conditions which may lead to otherwise unforeseen claim situations. A prospective claimant may be in the position of the lady who was visiting the California shores for the first time. It was a clear day and the Catalina Islands were just visible on the horizon. "Oh," she said, with obvious disappointment in her voice, "I thought the Pacific Ocean was much broader than that!"

Although impatience has been expressed in some quarters regarding reluctance of insurance companies to extend occupational disease coverage, it can be understood on review of the foregoing factors why well-managed casualty companies must necessarily approach with caution compensation insurance of concerns involving major occupational disease hazards.

WHAT ARE the accomplishments of the industrial hygiene divisions of the casualty companies? Perhaps the foremost achievement is one to which all the casualty companies have contributed through the cooperative work of their safety engineering and specialized industrial hygiene personnel together with industry in reducing hazards to health sufficiently that occupational disease compensation rates have been decreasing over the last fifteen years in all industrial classifications involving specific OD hazards. It is acknowledged that a num-

ber of agencies have contributed to this accomplishment but it is to be noted that the impact of the insurance company staffs has exerted a marked influence. Factors beyond the control of the conservation staffs of the insurance companies may cause a reversal in this trend in certain instances as, for example, the contemplated inclusion of a rate increment to cover payments for hearing loss due to industrial noise.

Data obtained by the insurance industrial hygiene divisions are of much value in supplementing medical information for determining whether or not a disability is due to an occupational cause. Where it has been found that there has been an excessive exposure to carbon disulfide and symptoms include mental derangement, the industrial hygienist would recommend that the claim department accept the case as occupational. But if it is contended that a welder has silicosis on the basis of the x-ray appearance of his lungs following work in an environment shown to contain insignificant concentrations of silica dust, then the industrial hygienist not only advises that the case be contested, he can also provide expert testimony in defense of the claim.

There was a time when a scientist contending that he wished to testify to the number of million particles of dust per cubic foot of air breathed by a worker would be considered a crackpot—or, to use a term heard during this Conference, a psychoceramic. But today there is an increasing appreciation of the importance of quantitative data on the extent and nature of the exposure to the health hazard alleged to be causing an occupational disease as an aid in arriving at a conclusion of whether or not the condition is truly occupational. It is anticipated that this trend will increase as its use demonstrates its value.

To what extent do the insurance companies maintain industrial hygiene divisions? Throughout the country some twenty-one of the leading insurance companies, agencies, and associations have personnel specially trained in industrial hygiene. Of fifty-four such persons, forty-four are members of the A.I.H.A. Sixteen of the companies maintain industrial hygiene divisions, fourteen of these having industrial hygiene laboratories.

It is our belief that others of the larger companies extending compensation insurance would find it profitable to establish such a laboratory. As stated in a recent issue of the AIHA QUARTERLY by the Association's president, WILLIAM R. BRADLEY, "So basic is the work of the industrial hygiene laboratory and so necessary are the results of laboratory technique with respect to employee health maintenance that . . . wherever is found the headquarters for industrial hygiene, there nearly always is found a chemical laboratory around which revolves the work of the entire industrial hygiene group." BRADLEY points out further that "Sound reasons for establishing separate laboratories for industrial hygiene . . . include the fact that new techniques are needed both for accurately obtaining samples of work-place air and for accurate and precise analysis of these samples." There are many casualty companies which do not have a sufficient volume of compensation business to justify a laboratory and technical services of their own but these could advantageously avail themselves of consulting services in this field for the more accurate evaluation and more effective control of occupational disease hazards.

AN INDICATION of the accomplishments of the divisions of industrial hygiene of the insurance companies is their contribution of publications in this field. In addition to the many special bulletins prepared on such subjects for circulation to the engineering staffs within the companies more than 250 technical and general papers on industrial hygiene subjects have been published by insurance company personnel in such periodicals as the AIHA QUARTERLY, the *AMA Archives of Industrial Hygiene and Occupational Medicine, Industrial Medicine and Surgery, Industrial and Engineering Chemistry,* and *Mechanical Engineering.*

Researches in industrial hygiene have been sponsored by insurance companies. These include such work as response of peritoneal tissue to dusts and methods of attack on the noise problem. Also, the casualty companies have been generous in allowing membership of their technical staffs on many committees covering various phases of industrial hygiene. It is of course to be acknowledged that much is invariably

gained from committee membership to repay time and expense incurred.

IN CONCLUSION, it is my conviction that this unique American institution, the industrial hygiene division in the casualty insurance business, is a strong and constructive factor in the industrial hygiene of the country. It provides the companies an intelligent approach to industrial hygiene problems, is effective in prevention of occupational diseases and in reduction of losses, and affords improved relations with agents and insureds. It assists industry in economic control of health hazards and, for the wage earner, it strives to obtain improved environmental conditions.

And as for industrial hygiene itself, I am sure that DONALD E. CUMMINGS, were he with us today, would agree with me that this unique American institution constitutes a real credit to the profession.

The Industrial Hygiene Engineer

HOW DOES the engineer help a plant get better working conditions? In the beginning his work was preventive in nature. His first appeal was for sanitation. The early texts held sanitation, ventilation and good lighting the three necessities for a healthful plant. On the heels of sanitation came good housekeeping. Orderly surroundings stimulate good work. Good housekeeping is an indicator of a well-run plant. . . . Occupational disease control was the next early activity of the industrial hygiene engineer and, of course, still takes much of his time. First requisite is that he know the chemical ingredients of every material used in his plant. . . . But this alone is not enough. Usually, the biggest exposure comes from breathing toxic materials, and so air samples taken at the workplaces are needed to tell the concentration of dusts, fumes and vapors that may be present. The chemist often works with the engineer in measuring these exposures. If dangerous conditions exist, the engineer sets out to correct them. . . . Because they are experienced in the appropriate techniques to measure and control community air and stream pollution, industrial hygiene engineers are giving much time to this activity. Atomic energy, which needs unique precautions and special instrumentation, has engendered a new branch of industrial hygiene known as health physics. As the use of radioactive tracers becomes more widespread, engineering control must provide the necessary protection. In addition to these duties, which are preventive, the engineer today contributes to the well-being of people in a constructive way. . . . Industrial hygiene has an exciting future, and a fascinating one. . . . Let's look at some examples. The factories of the so-called "hot" industries are deluxe structures compared with the shed-like quarters they had some decades ago. They have roof ventilators, man-cooling wind, mechanized operations, drinking fountains, salt tablets. There is no occupational disease problem. Yet, the heat is still troublesome. Five years ago a research program was begun. From it came knowledge of how to devise and apply *radiant heat* shields—and these get at the heart of the heat problem. Here was something constructive. Noise is another example. It can, perhaps, cause an occupational disease; it can be annoying; it can ruin conversation; it can make on-the-job training impossible. Before noise beomes a racket, the industrial hygienists need to find constructive answers. Not so spectacular are other examples: lighting and color—their effect on the individual—and how to light a job to fit a person's vision; what effect job conditions have on a person's urge to work, his absence rate; why some groups have different absence rates from similar groups doing similar work elsewhere. Then there's the almost untrod field of how to fit the modern machine, with its vast power and intricate controls, to the man, rather than the man to the machine. Not only must the control arrangement suit the man physically, but something is needed in this mass production age to stimulate rather than dull the man emotionally.

—Abstract of Remarks by W. G. HAZARD, at Industrial Hygiene Foundation's 17th Annual Meeting, Pittsburgh, November 20, 1952.

Nephelometric Determination of Nitrite Solutions

WILLIAM H. HILL and THEODORE HATCH*
Department of Occupational Health, Graduate of Public Health
University of Pittsburgh

THE REACTION between sulfamic acid and nitrous acid offers a method for the nephelometric determination of nitrogen dioxide. This reaction was discovered by Baumgarten and Marggraf[1] and follows the equation:

$$HNO_2 + H_2N.SO_3H = H_2SO_4 + N_2 + H_2O \quad (A)$$

Quantitative reaction occurs very quickly, especially in dilute solution, but may be retarded by appropriate neutralization and acidification with acetic acid.[2] Nitric acid does not interfere (in contrast to some of the colorimetric methods of NO_2 analysis), even when present in large amount, unless it be highly concentrated (better than 73%) when it reacts with sulfamic acid to form nitrous oxide, according to the equation:[3]

$$HNO_3 + H_2N.SO_3H = N_2O + H_2SO_4 + H_2O \quad (B)$$

It is obvious from equation (A) that two of the products of reaction are amenable to quantitative determination, namely the nitrogen by volumetric measurement, and the sulfuric acid by precipitation as barium sulfate and nephelometric measurement. The latter is feasible because barium sulfamate is water soluble, so that an excess of sulfamic acid does not interfere.

Baumgarten *et al*,[1] in the analysis of rather large quantities of NO_2, relied on the volumetric determination of nitrogen, for they found that the barium sulfate procedure always gave somewhat high results, accounted for by the fact that sulfamic acid and sulfamates hydrolyze appreciably at elevated temperatures, with the formation of sulfate. For the determination of low concentrations of nitrogen dioxide (10-200 PPM), one cannot use the volumetric determination of the small quantity of nitrogen released in the reaction, even with the use of the microazotometer as employed by Carson.[4]

The method described here depends upon determination of the amount of sulfuric acid formed in the reaction by precipitation at room temperature as barium sulfate, and measuring the precipitate by a nephelometric procedure. This does not require a large crystal size of the barium sulfate but, on the contrary, is benefited by a small size, which counteracts sedimentation of the sulfate, and hence makes it possible to carry out the reaction at a temperature at which hydolysis of sulfamic acid is negligible.

Nephelometry

NEPHELOMETRIC readings are influenced greatly by a number of factors, particularly particle size and shape, and are dependent upon the maintenance of stable and uniform dispersions. Particle size and settling rate could be affected by the concentrations of reagents, sequence of addition, the temperature of reaction, presence of agglomerating or coagulating ions, presence of suspension stabilizing and dispersion agents, pH of the reaction medium and other factors.

A literature review[5-14] suggested that the technique of nephelometric analysis, and the apparatus used therefor, have not been highly developed and that, in particular, the reference standards used left much to be desired. In general, standard precipi-

*The technical assistance of Mrs. Annette Kaufman is gratefully acknowledged.

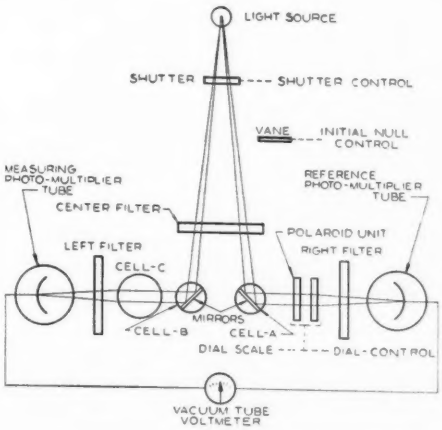


Fig. 1.
Simplified schematic of Fisher Nefluoro Photometer. Dashed lines indicate mechanical connections to panel control.

tations are prepared with known amounts of material under analysis and precipitations obtained with unknown samples compared therewith. Such a reference standard is subject to the same limiting factors referred to above and will have no greater stability than the unknown. These difficulties may be overcome, in part, through the use of standards which are selected for stability and relative permanence and the further use of a photometer designed for measuring scattered light of low intensity. We have made use of the Fisher Nefluoro-Photometer* which, as a nephelometer, employs a "generator" suspension and a standard suspension with which the unknowns are compared. The instrument is shown diagrammatically in Fig. 1. The recommended strength of the generator is at least two and one-half times that of the standard, which, in turn, is selected to represent the highest concentration which will be encountered in a series of analyses. In operation, the light emitted by the generator is attenuated by means of polarizers until it equals that of the 100% standard; the standard is then replaced by the unknown suspension, and the light emanating from the latter is measured by comparison with that coming from the generator.

*Appreciation is hereby accorded the Fisher Scientific Company for its kind c peration.

Development of Generator and Standard

THE USE of barium sulfate suspensions for the generator and standard proved to be unreliable because of instability and/or non-duplication of particle size from one suspension to another. Various attempts to stabilize the suspensions, disperse aggregations of particles and to control particle size by various additives were unsuccessful.

Satisfactory results ere obtained, however by two means: (1) the use of turbid polystyrene bars in place of suspensions of particles, and (2) a fine suspension of SiO_2 (Monsanto Aquasol WX-1) which, because of fineness of particle size and quality of dispersion, proved to be highly stable.

The use of a solid plastic bar with particles dispersed in it to produce the desired degree of light-scattering avoids the difficulties of a non-stable liquid suspension, provided the optical properties of the bars do not change with time. Two bars of different opacities were employed as generator and standard and comparisons run with different strengths of sodium nitrite representing NO_2 concentrations (in 2500 ml gas samples) of from 25 to 200 PPM.

A solution containing 0.03528 grams of $NaNO_2$ per liter was used for this purpose, of which 1 ml represents 10 PPM NO_2 (in 2500 ml gas samples). Appropriate volumes of this nitrite solution were run into a 100 ml volumetric flask, 25 ml of an aqueous 0.2% sulfamic acid solution and 5 ml of dilute HCl (1:4) were added, the mixture was diluted to the 100 ml mark, about 0.4 gram of $BaCl_2.2H_2O$ (10 small

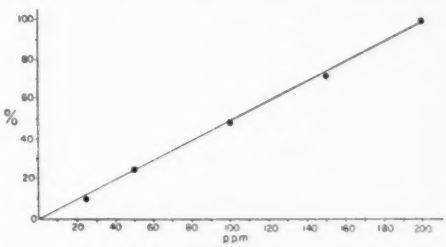


Fig. 2.
Nephelometric determination of nitrite by the sulfamate method. Polystyrene bars as generator and reference standard. PPM refers to equivalent NO_2 in 2500 cc gas volume.

TABLE I.

Standard	10-17-50 %	10-18-50 %	10-19-50 %	10-24-50 %	11-2-50 %
1	100	100	100	100	100
2	75	73.0	74.0	73.0	74.2
3	50 ± 0.2	48.5	49.1	49.0	—
4	25 ± 0.1	24.3	24.3	24.5	—
5	10 ± 0.5	10.0	10.0	9.6	10.3
6	5.3	5.0	5.0	5.0	5.0

scoops) was added, and the flask inverted 125 times. Fig. 2 shows typical results obtained.

While these tests indicated the soundness of the method, they were somewhat erratic. Mixing of the reactants by hand inversion of the volumetric flask was found superior to mixing on a mechanical shaking machine, and the number of inversions is quite important.

The use of solid sulfamic acid and elevated temperatures (50-65°C.) gave poorer results. The adjustment of the reaction mixture (before addition of the $BaCl_2$) to a pH of about three was found to be quite beneficial, especially for the lower concentrations. However, the adsorption of the indicator dyestuff by the precipitated $BaSO_4$ always lowered the results and therefore cast some doubt on this procedure.

A principal difficulty was that "green line adjustment" on the instrument (sensitivity control) was not possible in these tests with polystyrene bars as generator and reference standard, owing to the low turbidity and light-scattering by reflection of light by the polystyrene bars. Bars of a satisfactory turbidity were not available.

The SiO_2 aquasol gave more satisfactory results. One percent (by volume) of the commercial suspension in distilled water gave a generator of sufficient strength and 0.3% served well as the 100% standard,

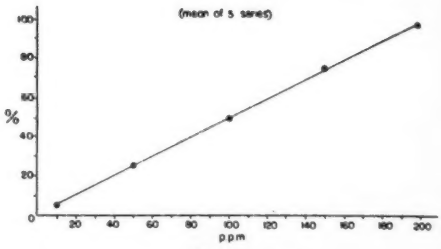


Fig. 3.
Nephelometric determination of nitrite by the sulfamate method. Aquasol as generator and reference standard.

being roughly equivalent to 200 PPM NO_2 in a 2500 ml gas sample. This standard was diluted further with appropriate amounts of distilled water to give a series of lower standards, representing 75%, 50%, 25%, 10%, and 5% of the original. Compared with each other over a period of three weeks, they proved to have satisfactory stability, as shown in Table I.*

Measurement of Equivalent NO_2 Concentration

USING SODIUM nitrite solutions of known strength to simulate NO_2 in reaction (A), the results shown in Table II and Fig. 3 were obtained in a series of repeat tests. The agreement among these results is highly satisfactory. Another series of tests with 10 aliquots of sodium nitrite solution, equivalent to 200 PPM NO_2 in 2500 ml gas samples, gave the results shown in Table III. These are in excellent agreement also and, since the same SiO_2 aquasol standards were employed as in the previous tests, the agreement with earlier findings demonstrates further that the standards were stable.

*They could, of course, have all deteriorated in like manner but this would be a remote possibility.

TABLE II.

Nitrite Conc., in PPM NO_2 per 2500 ml air	Series A 10-17-50	Series B 10-17-50	Series C (+) 10-18-50	Series D 10-18-50	Series E° 10-20-50	Mean of Series	Theory	Dev. of Mean from Theory	% Dev. of Mean from Theory
200	100.0	102.5	92.0	99.9	92.0	97.3	97.3	0	0
150	76.1	74.7	73.1	76.0	72.5	74.5	73.0	+ 1.5	+ 2.1
100	49.8	50.2	46.1	50.9	48.2	49.0	48.7	+ 0.3	+ 0.6
50	27.4	24.0	22.1	25.2	25.2	24.8	24.3	+ 0.5	+ 2.1
10	5.7	5.4	3.0	5.7	5.2	5.0	4.8	+ 0.2	+ 4.1

(+) Fresh nitrite and fresh sulfamic acid solutions used.
° Nitrite solution one day—and sulfamic acid two days old.

TABLE III.

Reading for Aquasol Standard 1	Deviation from Mean of Reading
96.0	0.4
96.0	0.4
95.8	0.2
95.0	0.6
95.0	0.6
95.3	0.3
95.7	0.1
96.2	0.6
96.2	0.6
95.2	0.4
Mean 95.6	Mean dev. 0.4

Purification of Sulfamic Acid

A PRINCIPAL source of error encountered in this work was the sulfuric acid content of commercial sulfamic acid which, according to the manufacturer,* may contain up to 1.5% calculated as SO_3. This gives rise to a substantial blank which cannot be neglected for low nitrite concentrations. Table IV and Fig. 4 are good illustrations.

While it is easy to determine a blank each time, it is not the best procedure. It should be very much better to procure a sulfate-free sulfamate, which also would eliminate the neutralization step employed and permit its use in solid form, just like the barium chloride. Unfortunately, no pure salt or pure free sulfamic acid was obtainable commercially. However, it can be made sulfate-free by the following procedure: the crude salt is dissolved in liquid ammonia, the solution filtered off from the insoluble ammonium sulfate, the filtrate evaporated and recovered pure ammonium sulfamate dried in a vacuum desiccator. Salt thus purified has been kept, well stoppered, for now nearly two years without a sign of decomposition. The purification process should also be applicable to other sulfamates, such as those of sodium and potassium.

*E. I. duPont de Nemours and Company.

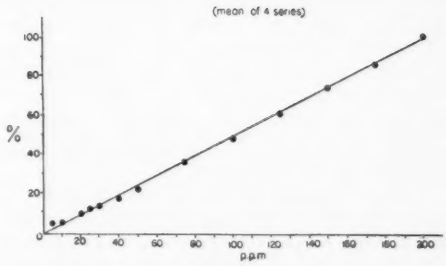


Fig. 4.
Nephelometric determination of nitrite by the sulfamate method. Aquasol as generator and reference standard. Shows influence of sulfuric acid impurity in sulfamic acid at low nitrite concentrations.

Determination of NO_2 in Air

WHEN dealing with low concentrations of NO_2 in air (*e.g.*, less than 25 PPM) a measured quantity (5-30 liters) is passed through two gas washing bottles connected in series and containing an aqueous solution (approximately 1%) of sulfamic acid (freshly prepared). At the end of the run, the contents of the bottles are transferred to a volumetric flask (100-250 ml) made up to volume, and aliquots analyzed in the

TABLE IV.

Nitrite Conc. in PPM NO_2 per 2500 ml air	Series A 12-1-50 x	Series B 12-2-50 "	Series C 12-4-50 +	Series D 12-4-50 (x)	Means of Series	Theory	Dev. of Mean from Theory	% Dev. of Mean from Theory
200	100.0	101.7		99.2	100.3	100.0	+ 0.3	+ 0.3
175	84.5	87.5			86.0	87.5	− 1.5	− 1.7
150	73.9	74.2			74.0	75.0	− 1.0	− 1.3
125	60.6	61.1			60.8	62.5	− 1.7	− 2.7
100	46.5	49.0			47.8	50.0	− 2.2	− 4.4
75	34.9	36.9			35.9	37.5	− 1.6	− 4.3
50			21.9	23.9	22.9	25.0	− 2.1	− 8.4
40			16.3	18.7	17.5	20.0	− 2.5	−12.5
30			13.9		13.9	15.0	− 1.1	− 7.3
25				12.2	12.2	12.5	− 0.3	− 2.4
20			10.0		10.0	10.0	0	0
10			4.7	5.9	5.3	5.0	+ 0.3	+ 6.0
5			5.5	3.8	4.6	2.5	+ 2.1	+84.0

x Fresh nitrite and fresh sulfamic acid solution.
" Same solutions as in A.
+ Fresh nitrite solution (diluted 10 times) and fresh sulfamic acid solution.
(x) Same nitrite solution as in C (but not diluted), and same sulfamic acid solution as in C.

manner described above. A blank is obtained on a portion of the sulfamic acid solution not used in the test in order to determine the amount of sulfuric acid formed by hydrolysis, and this value is deducted from the value obtained for NO_2, if found to be significant.

If a static method of testing is desired, for instance in the case of high NO_2 concentrations, gas samples of known volume are taken with conventional equipment, *e.g.*, a 500 ml gas pipette or Tutwiler burette. When the former is used, a known volume of sulfamic acid solution is introduced into the pipette containing the air sample, by means of a 20 ml Yale syringe,[15] the pipette is shaken vigorously for several minutes and a known volume of concentrated $BaCl_2$ solution is introduced in like manner. The resultant $BaSO_4$ suspension is brought to analysis as described above.

When using a Tutwiler burette, either barium chloride or sulfamic acid solution (preferably the latter) is used as the barrier liquid, and the second reactant is added from the graduated burette on top of the Tutwiler. The volume of the pipette below the lowest gas volume calibration mark must be ascertained so that the total volume of the liquids making up the final $BaSO_4$ suspension is known. Nephelometric analysis is carried out as described above.

Bibliography

1. Baumgarten, Paul, and Marggraf, Ilse: *Berichte* 63 I: 1019-1024 (1930).
2. Hahn, Friedrich L., and Baumgarten, Paul: *Berichte* 63 II:3028-29 (1930).
3. Baumgarten, Paul: *Berichte* 71 I:80-81 (1936).
4. Carson, W. N., Jr.: *Anal. Chem.* 23:1016 (1951).
5. Campo, Adel, Burnel, F., and Escolor, L. G.: *Bol. Acad. Ciencia* (Madrid) 2(7): 10-13 (1936).
6. Boggs, Hugh M., and Alben, Q. O.: *Ind. and Eng. Chem. Anal. Ed.* 8:97 (1936).
7. Stevens, Rollin E.: *Ind. and Eng. Chem. Anal Ed.* 8:248 (1936).
8. Goodhue, Lyle D.: *Ind. and Eng. Chem. Anal. Ed.* 10:52 (1938).
9. Mede, Grace, and Stavers, Elizabeth: *J. Lab. Clin. Med.* 25:624 (1940).
10. Treon, Joseph F., and Crutchfield, W. E., Jr.: *Ind. and Eng. Chem. Anal. Ed.* 14:119 (1942).
11. Saifer, Abraham, and Clark, Franklin D.: *Ind. and Eng. Chem. Anal. Ed.* 17:757 (1945).
12. Canals E., and Charra, A.: *Bull. Soc. Chim.* 12: 89-91 (1945)
13. Canals, E., Charra, A., and Riety, G.: *Bull. Soc. Chim.* 12:1055-58 (1945).
14. Lindsay, F. K., Braithwaite, D. G., and D'Amico, J. S.: *Ind. and Eng. Chem. Anal. Ed.* 18:101 (1946).
15. Patty, F. A., and Petty, G. M.: *J. Ind. Hyg. and Tox.* 25:361-365 (1943).

Industrial Health Practices

During the week of March 9, 1953, the Bureau of Adult Health of the California Department of Public Health presented its Third Annual Institute on Industrial Health Practices. Los Angeles was the site of this year's three-phase program which consisted of, Section 1. Orientation to the State Laboratory, Section 2. Lectures, and Section 3. Laboratory Exercises. One hundred persons attended the 10 hour lecture course. Twenty-one engineers, sanitarians and technicians received 15 hours of instruction on instrumentation and chemical analyses during the Laboratory Session. The Laboratory Session covered the following material: Measurement of Air Flow, Dust Sampling and Counting, Physical Factors of Environment, Determination of Organic Solvents, and Detection and Determination of Gases. The Lecture Session was divided into three parts: Introduction to Occupational Health; Health in Industry; Public Health Preventive Methods. Twelve papers were presented: "The Occupational Diseases," by A. C. EINERT, M.D.; "The Environment," by B. R. HUBBARD; "Chemistry," by W. J. ROBERTS; "Medical Programs," by A. C. EINERT, M.D.; "Industrial Nursing," by E. TULJUS; "Compensation and Rehabilitation," by A. C. EINERT, M.D.; "Medical Prevention and Control," by A. C. EINERT, M.D.; "Industrial Sanitation," by J. R. YOUNG; "Engineering," by J. R. YOUNG; "Industrial Dust," by P. E. CAPLAN; "Other Dusts and Chemical Contaminants," by R. R. JAMES; and "Physical Factors in the Environment," by B. H. MILLER.

Fly Ash Collection
IN INDUSTRIAL EXPERIENCE

B. S. NORLING, E. I. du Pont de Nemours & Company, Inc.
Wilmington, Delaware

UNTIL RECENT YEARS, the atmosphere was considered a natural means of waste disposal. Almost without exception the furnace gases from homes, schools, small and large industries, alike, discharged their furnace gases with all the products of combustion into the atmosphere. With the increase in population and concentration of industry, this practice cannot be continued without deleterious effects. This paper discusses the problems involved, citing as an example the installation of fly-ash collectors and the disposal system for a large existing industrial plant. This installation was made in a plant that had a rather modest start in 1928. It was built approximately ten miles from the nearest city in a wooded valley apart from other industries and in a very sparsely settled area. At that time, little thought was given to a possible nuisance caused by fly ash. The small amount of fly ash dispersed into the atmosphere during the early years of growth was not a nuisance. The plant did thrive and its growth was exceptionally rapid, reaching a size several times that of the initial installation. Immediately after the ending of World War II, a number of small industrial plants moved into the valley and the community became thickly settled. A nice residential area was built and soon afterwards complaints were received from dust deposits. These complaints were investigated and found to be due, largely, to fly ash, and it was apparent that a clean-up program was in order. The development at this plant may be considered as typical of the industrial growth of many of the communities in the United States.

Presented before the Symposium on Air Pollution Controls sponsored jointly by the Fuels Division, the Power Division, and the Committee on Air Pollution Controls of the American Society of Mechanical Engineers, December 2, 1952, New York, New York.

A survey was made to determine the plant's contribution to the conditions causing the nuisance. Tests were run to determine the fly-ash emission rates from the power house stacks. At the same time, the downwind concentration of fly ash at ground level was also measured. The fly ash concentration at ground level was found to be from two to seven times in excess of values normally considered to be acceptable. The decision was then made to proceed with the installation of collectors.

Plant Steam Generating Capacity

IN THE power house there are eight pulverized coal-fired boilers. Three of the boilers have a nominal steam-generating capacity of 80,000 lbs. per hour while the other five are rated at 130,000 lbs. The steam pressure is 450 psig with a total temperature of approximately 700°F. The peak steaming rate is 930,000 lbs. per hour and the average is approximately 750,000 lbs. per hour. This plant is in continuous operation and load variations are due to seasonal and production changes. The coal burned is obtained from a wide variety of mines from Virginia, West Virginia and Pennsylvania.

The ash content of the coal varies from 6% to 12% with the average around 9%. The average ash content has been slowly rising. Of the ash in the coal, approximately 15% drops into the furnace bottom or hoppers and the remaining 85% is carried through the boiler and out the stack as fly ash with the flue gas. The carbon content of the fly ash varies quite widely. Because samples are taken at irregular intervals, a true average carbon content is not available. It has been estimated to be in the neighborhood of 20%. The carbon in the ash not only increases the quantity of

fly ash, but it decreases the bulk density. Random samples taken from the collector hopper indicate that the bulk density of the ash with 20% carbon varies between 30 and 35 lbs. per cubic foot when poured into a container as it does in a collector hopper. Tapping or shaking the container packs the ash and thus reduces the volume and increases the bulk density.

The designer can readily appreciate the effect on the collector hopper storage capacity when the ash content of the coal and the carbon content of the ash increases. The design may have been based on the removal of the ash each eight-hour shift, but with an increase in ash and carbon content, the volume required increases rapidly and the hopper may have to be emptied at four-hour intervals.

Selection of Collectors

THERE WERE numerous commercial collectors available from which to choose for this installation. The range in available collection efficiency approaches nearly complete removal of the last traces of ash, but, with the more thorough clean up comes a rapid rise in cost. Another limitation was the space available, since no provisions had been made originally for the installation of collectors and this too increases the cost.

The question that naturally arises then is what collection efficiency is required? This is a difficult question. A heavy capital investment will cut deeply into the profitable operation of the plant since power costs must be included in the cost of the manufactured product with no assurance that the product sale price can be increased to cover the additional investment. At present, the collected fly ash cannot be considered as salable. There will be some return through reduced induced draft-fan maintenance but this is more than offset by the addition of operating and maintenance of the collector installation. Thus, the installation of fly-ash collectors and the facilities for disposal become a costly burden on the operation of the plant. Nevertheless, abatement is a plant responsibility and good community relationship is the compensating return.

The selection of the type of collectors was made on the basis of the cost of the installation and the performance that was to be expected. A condensed summary of the results is shown in Table I.

TABLE I.
FLY ASH COLLECTOR INSTALLATION

	Mechanical Collectors	Electrostatic Precipitators
Steam Generation (Ave) #/hr.	750,000	750,000
Coal Burned #/hr.	73,500	73,500
Collector Efficiency %	86	95
Fly Ash Disch. to Atmos. #/hr.	940	340
Flue Gas—Dust Loading gr./c.f. @ 500°F and 50% excess air	.25	.09
Installed Cost	$420,000	$545,000

These figures are approximate costs estimated from preliminary information prior to the design and layout of the system. The figures do not include facilities for disposing of the fly ash as existing facilities were available. The installation of electrostatic precipitators was especially difficult because of space limitations. The estimated increase in cost for the electrostatic precipitators over that of the mechanical collectors was $125,000. The expected average reduction in fly-ash emission is 600 lbs. per hour. The incremental installation cost for the more thorough clean up is costly. There is a small reduction in cost of power consumption but not enough to justify the higher cost alone if the clean up is adequate with the mechanical collectors.

There were no local ordinances establishing the required collection efficiencies or limiting emission rates. Lacking any such mandatory regulation, the model ordinance suggested by the ASME was used as a guide for it is generally accepted and is one of the more stringent ordinances. The ASME Code required that the dust loading of stack gases shall not exceed 0.25 gr./cu. ft. with the exception that a collector efficiency of not more than 85% is required for new plant installations and not more than 75% for plants constructed prior to the effective date of the ordinance. The ordinance in the nearest city is far more lenient than the ASME Code. The atmospheric dust loading, at ground level downwind from the stack, was expected to be reduced to less than 0.55 grains per 1,000 cu. ft. as this is considered acceptable to a normal city. Collectors with an average efficiency of 85% or better would then be expected to give the required clean up. On this basis, mechanical collectors were accepted.

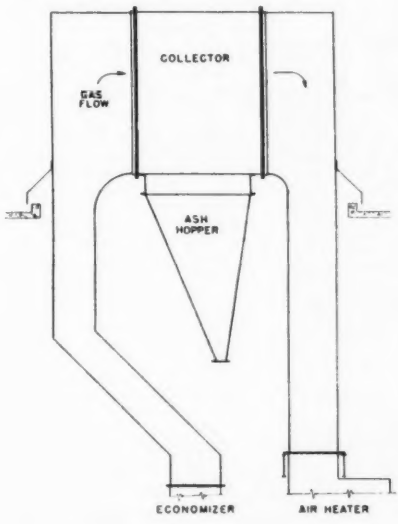


Fig. 1.

A mechanical collector does not give a clear gas leaving the stack. The very fine particles that remain give color to the gases; and, if there is a high carbon content in the particles, then the appearance of the discharge gases will be dark, even though the dust loading of the gas is light. The color of the gases leaving the stack, though it was carefully considered, was not a determining factor. After the completion of the installation of collectors at this plant, a local civic organization voluntarily wrote a letter to the company expressing its appreciation and specifically stated that there was no longer a dust nuisance in the community.

Installation of Collectors

THE COLLECTORS were designed and so arranged that the units could be put into service during the normal boiler overhaul period. There were eight collectors and the overhaul period extended from the first of April to the first of November. The first unit was to be tested and if the performance was below that expected, corrections were to be made on the installations to follow. It was found possible to install the collectors in the allotted time and performance of the collectors met the guarantee.

A cross section of the installation of one of the collectors is shown in Fig. 1. There were three different equipment arrangements required for the eight collectors. The equipment configuration was selected to fit the limited space available. As shown, this collector was installed in the roof and in the flue-gas circuit between the economizer and the air heater. The flue gas was drawn vertically downward through the air heater by the induced draft-fan setting on the operating floor. The induced draft fan required a larger impeller and a larger driving motor to overcome the additional resistance to the gas flow imposed by the collector. The collector hopper extended through the roof where a pneumatic system was installed to remove the fly ash.

The fly ash was conveyed to the basement where it passes through a multiple jet water ejector. The slurry is then pumped to a fill approximately one-half mile away. The disposal area is a low section on the plant property made into a pond by diking with the soil taken from the pond area. It is expected that the pond will provide a disposal area for the next four years. It will then be necessary to provide other means for disposing of the ash.

While it was not the case in the installa-

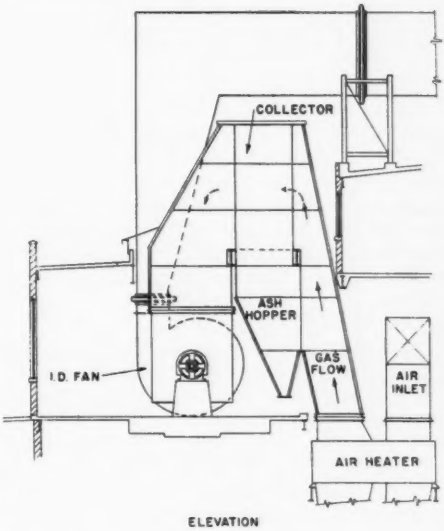


Fig. 2.
Showing the cramped position in which one collector was installed.

TABLE II.
FLY ASH COLLECTION TESTS

Test No.	Units	1	2	3	4
Steam Flow (Corrected)	#/hr.	79,500	79,500	91,000	60,000
Steam Temp.	° F	640	635	630	625
Steam Press.	PSIG	418	418	419	418
F. W. Temp.	° F	255	255	255	255
Gas Temp. at A. H. Outlet	° F	378	378	375	
CO_2-Boiler Outlet Recorder	%	13.5	13.4	13.9	11.6
Collector Press. Drop	In H_2O	2.5	2.5	2.85	1.75
Inlet Duct Gas Temp.	° F	322	322	326	295
Gas Flow at Duct Temp. (Pitot)	CFM	41,500	41,500	45,400	32,900
Sampling Time	Min.	128	128	128	128
Gas Sampled at Duct Temp.	Cu. Ft.	1823	1824	1998	1458
Ash Collected by Sampler	Grams	239.2	248.4	287.2	158.1
Dust Loading at Duct Temp. (Grains)	GR/CF	2.02	2.10	2.22	1.67
Outlet Duct Gas Temp.	° F	315	315	323	289
Gas Flow at Duct Temp. (Pitot)	CFM	44,400	44,400	48,700	34,900
Sampling Time	Min.	128	128	128	128
Gas Sampled at Duct Temp.	Cu. Ft.	1974	1966	2159	1540
Ash Collected at Sampler	Grams	32.6	37.6	34.0	28.7
Dust Loading at Duct Temp. (Grains)	GR/CF	.255	.295	.243	.287
Hopper Catch					
Ash Caught During Test	Pounds	1743	1654	1787	936.5
Duration of Test	Min.	180	170	150	160
Ash Caught Per Minute	#/Min.	9.7	9.74	11.91	5.86
Ash Caught Per Hour	#/Hr.	582	584	715	352
Efficiency—Actual					
Inlet vs Outlet	%	86.5	85.0	88.3	81.8
Catch vs Outlet	%	85.7	83.9	87.7	80.7
Catch vs Inlet	%	80.9	78.2	82.5	74.6
Expected Efficiency					
Inlet Conditions	%	90.4	86.0	89.95	83.75

Test Efficiency Based on #/Min of Dust

$$\text{Inlet vs. Outlet, Efficiency} = \frac{\text{Inlet-Outlet}}{\text{Inlet}} \times 100$$

$$\text{Catch vs. Outlet, Efficiency} = \frac{\text{Catch}}{\text{Catch} + \text{Outlet}} \times 100$$

$$\text{Catch vs. Inlet, Efficiency} = \frac{\text{Catch}}{\text{Inlet}} \times 100$$

tion described here, the ash removal and disposal system may represent a very large part of the total investment and become the major operating expense. In one of the other plants, this item represents an investment of well over a quarter of a million dollars. The operating costs have not been definitely established but ash disposal is inherently a high maintenance cost item.

Collector Performance Tests

THE PERFORMANCE test results of the first collector are shown in Tables II and III. There were tests run on other collectors with essentially the same results. The actual efficiency is expressed in three ways and the expected efficiency is based on the particle size determined from the sample taken at the inlet of the collector. The particle size analysis is shown in Table III and was determined by the air elutriation method. The technique used in the air elutriation method varies with the user and the results may vary quite widely. The expected collector efficiency is based on the particle size analysis and therefore, varies with the analysis. It might be well to mention here that the accuracy of particle size analysis determined by air elutriation for particle sizes below 10 microns is questionable. A standard test code is needed for determining the particle size.

Dust Particle Size Defined

THE ASME CODE defines a dust as gas and air-borne particles larger than one micron in "mean diameter." Some of the municipal ordinances have defined a dust nuisance as being made up of gas and air-borne particles larger than ten microns. The efficiency of the mechanical collector drops off rapidly as the particle size decreases below ten microns. It is well then to know specifically what is meant by "mean diameter." The particles of fly ash are certainly seldom regular spheres but comprise a heterogeneous dust consisting of irregular shapes. The term "mean diameter" of an irregular shaped particle is assumed primarily to be the diameter of a sphere

TABLE III
PARTICLE SIZE ANALYSIS

Particle Size Microns	Test No. 1 Inlet %	Test No. 1 Outlet %	Test No. 1 Catch %	Test No. 2 Inlet %	Test No. 2 Outlet %	Test No. 2 Catch %
(—) 7.5	15.39	40.75	20.03	31.19	62.80	24.0
7.5—10.0	13.39	25.20	12.06	8.61	24.11	10.0
10.0—15.0	20.47	21.99	24.68	17.39	9.46	23.0
15.0—20.0	11.69	9.29	9.02	9.18	1.88	8.0
20.0—30.0	14.92	1.65	15.27	14.56	1.08	19.0
(+) 30.0	24.14	1.12	18.94	19.07	.67	16.0

Particle Size Microns	Test No. 3 Inlet %	Test No. 3 Outlet %	Test No. 3 Catch %	Test No. 4 Inlet %	Test No. 4 Outlet %	Test No. 4 Catch %
(—) 7.5	20.44	72.79	19.0	32.19	71.26	22.0
7.5—10.0	10.30	14.18	9.0	9.68	14.84	17.0
10.0—15.0	14.55	9.20	20.0	17.56	11.17	20.0
15.0—20.0	7.53	1.18	11.0	9.06	1.31	9.0
20.0—30.0	17.88	1.63	18.0	12.25	.77	14.0
(+) 30.0	29.30	1.02	23.0	19.26	.65	18.0

which would behave the same as the particle under the same circumstances. In sedimentation or elutriation, for example, the principle used is that a particle falling with a certain velocity is assigned a mean diameter which corresponds to the diameter of a sphere that would fall at the given velocity calculated from Stoke's Law. In the sieving analysis a particle that will just pass through a 325 mesh (Tyler) sieve is assumed to have a diameter of forty-four microns because the apertures are square averaging forty-four microns on a side. Irregular-shaped particles will have different behavior characteristics under different circumstances and the analysis by one method will not agree in particle size with that of another method. For instance, a particle shaped like a flat disk may be classed as a large size in the sieving method, but because it settles slowly in sedimentation, it would be classed much smaller in diameter by the latter method. There is also the danger of reducing the size of the particles by attrition while determining the particle size. The expected or guaranteed collection efficiency of a collector must therefore be based not only on a given particle size distribution, but the method of determining the particle must also be stated. Obviously a standard test code is needed.

Experience at Other Plants

THIS DISCUSSION has dealt with the problems encountered in one plant. It may be of interest to look at a summary of test data taken at a number of other plants. Tables IV, V, and VI briefly summarize pertinent information from several tests.

Table IV: A summary of particle size distribution, dust loading, carbon in the fly ash, and the specific gravity of the ash for various methods of firing.

Table V: A comparison of mechanical fly-ash collector efficiencies as determined by test compared with the manufacturer's expected efficiencies under the test conditions.

Table VI: A comparison of fly-ash emission from the power house stacks with the limitations recommended by the ASME and A.P.S.P.A.A ordinances.

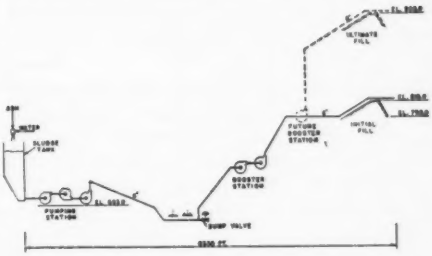


Fig. 3.
Schematic diagram of a sluicing system used in the disposal of fly ash.

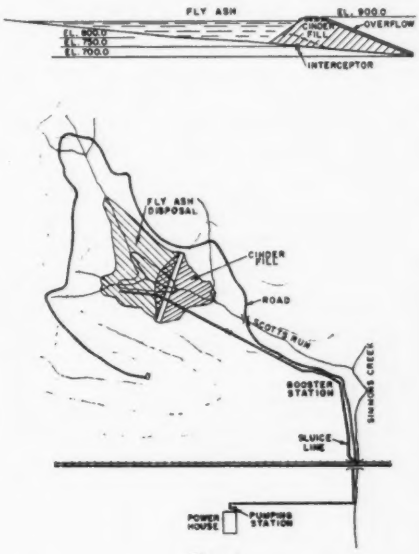


Fig. 4.
A map showing the route followed by the sluicing system shown in Figure 3.

TABLE IV.
BOILER OUTLET FLY ASH TEST DATA FOR PULVERIZED FUEL, SPREADER AND UNDERFEED STOKER UNITS

		Pulverized Fuel Units[1]			Spreader Stoker Units[2]			Underfeed Stoker Units[3]		
	Units	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Fly Ash Size Distribution										
% Less Than 10 Microns	%	58	26	41	47	15	28	28	25	26
% Less Than 20 Microns	%	77	48	60	64	20	41	45	43	44
% Less Than 40 Microns	%	98	70	87	78	23	57	63	55	59
% Less Than 80 Microns	%	99	89	97	97	31	69	78	76	78
Boiler Outlet Dust Loading at 500°F. and 50% Excess Air	gr./c.f.	1.95	0.81	1.4	1.98	0.16	0.7	0.07	0.06	0.065
Carbon in Fly Ash	%	36	6	15.7	77	42	55	31	24	28
Specific Gravity		2.5	1.9	2.1	2.2	1.9	2.0	2.4	2.3	2.35
Spreader Stoker Firing Rate[4] # Coal/Hr./Sq. Ft. of Grate		—	—	—	40.5	21.4	—	—	—	—

Fly Ash Size Distribution and Boiler Outlet Dust Loading
[1]Based on 22 tests; [2]Based on 17 tests; [3]Based on 2 tests; [4]Reinjection from Boiler Hopper Only.

Summary

MOST OF THE present-day ordinances have been enacted or revised as a result of local studies made following 1946. The need for fly-ash collectors was fully recognized by few industrial plants prior to World War II, but little could be done about it during the war. In a few cases provisions were made for a future installation. If the collectors are installed when the plant is built, the cost is but a fraction of the cost to install them later, particularly when no provisions are made for the future installation. The mechanical collector has in general been a lower cost installation than the electrostatic precipitator and it has been used more widely in the industrial plants. It does not give the clean up that is possible with the electrostatic precipitator. If the electrical characteristics of the ash are not suitable, the precipitator may also give a performance far below that expected. There seems to be a field for each type. At present, a combination of the two types appears to overcome many of the limitations. However, cost and space prohibit the use of the combination on most existing boiler plants. The higher efficiency mechanical collectors limit the fly-ash emission rate sufficiently to meet nearly all of the existing ordinances except the A.P.S. P.A.A. ordinance applied to large plants. It is to be expected that future ordinances will become more restrictive and the improvement in the application of collectors or any other means of reducing atmospheric contamination must be given careful study in considering future installations.

TABLE V.
COMPARISON OF FLY ASH COLLECTOR EFFICIENCIES

Plant	Type Firing	Inlet Dust Size % Less Than 10μ	Efficiencies, % Test	Efficiencies, % Expected
A	Spreader Stoker	23.6	92.2	93.1
A	Spreader Stoker	29.3	87.6	92.0
A	Spreader Stoker	25.7	83.4	84.2
B	Pulverized Coal	43.1	87.9	86.6
C	Pulverized Coal	44.7	83.6	86.4
C	Pulverized Coal	28.0	87.5	90.4
C	Pulverized Coal	40.0	86.1	86.0
C	Pulverized Coal	31.0	89.3	90.0
C	Pulverized Coal	43.0	82.9	83.8
D	Pulverized Coal	47.6	67.6	77.7
D	Pulverized Coal	44.9	71.3	78.9
D	Pulverized Coal	49.1	77.4	81.5
D	Pulverized Coal	51.4	77.1	80.7
D	Pulverized Coal	49.1	72.3	81.5
E	Spreader Stoker	15.5	90.5	88.0
E	Spreader Stoker	15.1	93.6	89.0

TABLE VI.
COMPARISON OF FLY ASH EMISSION FROM POWER HOUSE STACKS WITH ASME AND APSPAA ORDINANCE LIMITS

Plant	Stack No.	Steam Load lbs./hr.	Fly Ash Discharge Actual or Expected Gr./C.F.**	Fly Ash Discharge Actual or Expected lbs./hr.	Ordinance Limit APSPAA lbs./hr.	Ordinance Limit ASME lbs./hr.
A	1	80,000	0.11	45	180	110
	2	40,000	0.11	23	90	55
B	1	350,000	*0.19	*430	454	502
	2	440,000	*0.19	*530	514	630
	3	510,000	*0.19	*628	558	730
	4	350,000	*0.19	430	454	502
	5	200,000	0.19	246	334	287
C	1	470,000	0.24	605	533	630
	2	390,000	0.24	500	482	520
D	1	140,000	0.25	162	272	172
F	1	130,000	*0.21	*140	260	185

*Expected
**Corrected to 500°F and 50% Excess Air

Notes on Determination of Lead by Dithizone Method

I. EFFECTS OF IMPURITIES IN CYANIDE

HERVEY B. ELKINS, Ph.D., Chief of Laboratory
Division of Occupational Hygiene
Massachusetts Department of Labor and Industries

THE DETERMINATION of microgram amounts of lead by the dithizone method is greatly simplified by the fact that most other heavy metals are strongly complexed by cyanide. Hence, the addition of this reagent is universal in dithizone lead procedures.

The literature does not reveal any particular trouble from cyanide as a reagent in this determination. A review of 15 references discloses that the vast majority (13) use potassium cyanide, while only two employ the sodium salt. Most authorities state or imply that no treatment of this reagent is necessary. A few recommend extraction with dithizone solution, either as a matter of routine, or "if necessary."

One reference mentions interference from phosphate, and recommends recrystallization.[1] One method states, "There must be no sulfide present in the KCN or other reagents."[2]

This laboratory has employed a modification of the Ross-Lucas method,[3] in which lead is co-precipitated with calcium oxalate, for the determination of lead in urine. Because perchloric acid is employed in the digestion, sodium cyanide is used, in order to prevent the precipitation of potassium perchlorate, which would be formed if potassium cyanide were added.

When details of the method were being worked out, most of the reagents were purified. In case of sodium cyanide, this was accomplished by dithizone extraction. As lead-free reagents became available, purification steps were eliminated, and for several years the only reagent which is routinely purified has been ammonium oxalate.

Basically the same procedure is used for lead in air as for lead in urine, and the same reagents, including sodium cyanide, are employed. During a period of more than 12 years, approximately 6,000 urine samples and 1,500 air samples were analyzed for lead, with apparently successful results. It is significant that the only determinations shown to be erroneous were some based on a standard solution which had deteriorated, part of the lead having apparently deposited on the walls of the bottle, and some analyses of old, unpreserved urine samples, where the same phenomenon occurred.

It was disconcerting, therefore, when a number of urines, some from workers known to have lead exposure, failed to show any lead at all. This event followed the preparation of a new solution of sodium cyanide from a freshly opened bottle. It was shortly established that the cyanide was in some way supressing the lead and preventing its extraction by dithizone. Table I shows a typical experiment on the effects of the cyanide solution made at this time.

If only one drop of cyanide was added, the suppression of interfering metals was incomplete, resulting in a high blank value.

TABLE I.
APPARENT LEAD CONTENT VS. FRESH SODIUM CYANIDE

NaCN added—drops	1	2	4	8
No lead added	6 ug.	2.0 ug.	1.3 ug.	0.3 ug.
10 ug. lead added	11.5 ug.	9.0 ug.	5.8 ug.	2.0 ug.

If enough cyanide (4-8 drops) was used to take care of the amounts of such metals which could be expected in air or urine samples, the recovery of lead was poor.

Other brands and lots of sodium cyanide were tried, but in each case addition of eight drops of the 25% solution completely supressed 10 ug or so of lead. A fresh solution prepared from the residue in a nearly empty bottle of sodium cyanide reagent worked perfectly, however.

Several methods of treating the unusable solutions were tried. Addition of a reducing agent had no effect. Hydrogen peroxide improved the reagent materially, but apparently oxidized some of the cyanide. Aeration of the solution had a slight effect only. Extraction with chloroform was useless, but the solution was usable after extraction with dithizone solution.

It was also found that better recoveries were obtained if the cyanide was added to the strongly acid solution, before addition of hydroxylamine. If the solution was only weakly acid, inferior results followed.

Inquiries were made of the reagent manufacturers, and several suggested that the presence of sulfide in the cyanide might be responsible for our difficulties. The manufacturers' analyses of the various samples of sodium cyanide indicated sulfide contents of 0.003% to 0.005%.

It was discovered accidentally that cyanide solutions, which suppressed lead when freshly prepared, were suitable for use after aging a few days. It was also found that the reagent from a freshly opened bottle was worse, from our standpoint, than reagent from a bottle that had been opened some time before. Typical results showing the effect of aging in the solid state and in solution are shown in Table II.

Eight drops, or ½ ml, of the 25% solution of fresh sodium cyanide was found to suppress about 18 ug of lead. This would correspond to 2.8 ug of sulfide sulfur, or about 0.002% in the original reagent, in comparison with the analysis value of 0.005%.

After standing for one week, all the above solutions could be used for lead determination.

Behavior of Potassium Cyanide

A TOTAL of eight samples of KCN were tested. Thirty-three percent solutions, the equivalent of 25% solution of NaCN in cyanide content, were prepared.

Two solutions were satisfactory for lead determination, but turned dark, almost black, within two weeks.

Two solutions were satisfactory for lead determination, and remained clear for several weeks, but one finally turned dark.

One solution suppressed lead, and remained clear for several weeks, finally turning dark.

Three solutions were satisfactory for lead determination, and remained colorless for at least 19 months. These three samples were of foreign manufacture.

Discussion

IT APPEARS reasonably certain that the sulfide present as an impurity in the sodium cyanide used, and in one sample of potassium cyanide, is responsible for the failure of fresh cyanide solution to permit complete extraction of lead. The oxidation of the sulfide, very slowly in the solid material, and more rapidly in solution, explains why aged solutions are satisfactory while fresh solutions are unusable.

Why has this observation not been made heretofore? One reason is the almost universal preference for potassium cyanide, usually sulfide free, over sodium cyanide. Another is the fact that purification, by

TABLE II.
EFFECT OF AGING ON SODIUM CYANIDE

Reagent	Bottle Opened	Sulfide Analysis	Volume Cyanide Used	Recovery of 20 ug Lead	
				Fresh Solution	Solution One Week Old
I	Approximately 21 months	0.003%	8 drops	42%	92%
II	Approximately 21 months	0.003%	8 drops	61%	113%
III	Approximately 21 months	0.003%	8 drops	70%	101%
IV	Approximately 21 months	0.005%	8 drops	57%	116%
V	One day	0.005%	8 drops	12%	108%
V	One day	0.005%	4 drops	54%	110%

dithizone extraction, in some manner removes or neutralizes the sulfide. And finally, unless the worst possible conditions are present, i.e., freshly prepared solutions from a newly opened bottle of reagent, complete suppression of lead is improbable. In many cases a partial suppression of lead would be undetected, but nevertheless lead to erroneous results.

Sodium cyanide has certain advantages over potassium cyanide as a reagent, notably where colorless solutions are desired, where the potassium ion is undesirable, and where cost is a factor. Its chief drawback is the presence of sulfide, which can be destroyed by allowing the solution to age.

References

1. HUBBARD, D. M.: *Ind. Eng. Chem., Anal. Ed.*, 9:493 (1937).

2. Du Pont de Nemours, E. I. & Company, Wilmington, Delaware: Determining Traces of Lead, Zinc and Chromium in "Coppralyte" Copper Plating Solutions, (SP 18-649).

3. ROSS, J. R., and LUCAS, C. C.: *J. Biol. Chem.*, 3:285, (1935).

II. INTERFERENCE FROM BISMUTH AND TIN

HERVEY B. ELKINS and BENJAMIN P. W. RUOTOLO, M.D.

IN DETERMINATION of lead by the dithizone procedure, interference from most other heavy metals is prevented by addition of sufficient cyanide to form stable complexes. Bismuth, stannous tin and thallium, as well as lead, do not complex strongly with cyanide. In the presence of these metals, steps other than the addition of cyanide must be taken to prevent interference with the lead determination.

A limited review of the literature reveals that most authorities ignore thallium as being too rare to be, in practice, a problem. On the other hand, tin and bismuth cannot be dismissed as casually.

While tin compounds are not commonly associated with lead paints or other lead compounds in industrial use, the most common forms of metallic lead are alloys containing tin, such as solder, type metal, and bronze. Because of the low volatility of tin, its fumes are probably not present in significant amounts when most such alloys are melted, but tin oxides undoubtedly occur in the dross which is an important source of lead dust. Tin is also present in the dust when alloys containing this metal are ground or sanded. Thus tin is a potential contaminant in a substantial percentage of the air samples taken for lead, and the possibility of its presence in the blood or urine of workers exposed to these atmospheres should be considered.

Bismuth is of less frequent industrial occurrence than tin, but when it is used in melted alloys its volatility, being greater than that of lead, suggests the possibility that bismuth fumes will be present. A more important source of bismuth is in various drugs which threaten the contamination of body fluids and tissues with this element.

Most analytical methods for lead employ oxidizing agents which will oxidize stannous tin to the stannic state, thereby preventing interference from this element. While some procedures feature steps specifically designed for removal of bismuth, many ignore interference from this metal, or provide for its removal only if necessary.

Tin

THE METHOD used in our laboratory has optimistically ignored the danger of interference from tin and bismuth. We employ hydrochloric acid where others use nitric acid. Thus our usual procedure for lead in air involves addition of HCl to the impinger or precipitator suspension, or to the filter paper samples. If the sample was of a dust of a copper-tin-lead alloy, the presence of stannous tin in the resultant solution would be probable. None of the secondary steps in the procedure is designed to eliminate stannous tin.

Samples of filings from a copper coin, (coinage bronze reported to be approximately 4% tin) and from a sample of manganese bronze, reportedly containing tin and lead free, were treated with approximately 3N HCl. After standing in the cold overnight, aliquot portions were tested directly for lead, after addition of

citrate, cyanide, etc., by the usual dithizone procedure. Positive results were obtained, corresponding to approximately 0.3% lead in the coin, and 0.2% in the manganese bronze.

Other portions of the above solution were analyzed by the procedure for lead in urine, starting with co-precipitation with calcium oxalate. The results obtained agreed with those found by direct dithizone extraction.

Stannous chloride was found to give a positive reading on direct extraction with dithizone, under the conditions used for lead, but when the co-precipitation procedure was used, negative results were obtained.

It is concluded that our hydrochloric acid treatment of lead-tin alloy does not lead to erroneously high results.

Bismuth

BISMUTH compounds are sometimes administered parenterally in the treatment of syphilis and are taken orally for diarrhea and occasionally for stomach disorders. In addition, patent medicines containing bismuth are available.

Urine samples from two individuals under bismuth treatment for syphilis, from two persons who took tablets of bismuth subcarbonate totalling 1 gm daily, for three days, and normal urine samples to which bismuth was added, were analyzed by our standard lead in urine method, with the results given in the table.

Although the brown color of bismuth dithizonate is easily distinguishable from the red shade of the dithizonates of lead and of most other heavy metals, solutions containing an excess of free dithizone are an uncharacteristic blue or violet color. Thus in the mixed color method interference from bismuth in small to moderate amounts (as in the samples above) could not be detected from the appearance of the dithizone extract.

It is apparent from Table I, that erroneously high lead results may be expected when urine samples from patients undergoing intramuscular bismuth therapy are analyzed. On the other hand, it appears that ingestion of bismuth, if not prolonged, at least, will not affect the results of such analyses.

TABLE I.
INTERFERENCE OF BISMUTH IN LEAD IN URINE ANALYSIS

Individual	Source of Bismuth	"Lead" found, mg/L
A	Intramuscular injection	0.10
B	Intramuscular injection	0.12
C	Pretreatment	0.10
C	Oral (1 gm/day for 3 days)	0.06
D	Pretreatment	0.04
D	Oral (1 gm/day for 4 days)	0.06
E	Added direct to urine (0.9 mg/L)	0.15
E	Added direct to urine (0.2 mg/L)	0.10

The procedure can, of course, be modified to eliminate bismuth interference, but such a change usually involves at least two additional steps, adding substantially to the length of the analysis. This course should be taken if the probability of bismuth contamination is substantial.

In Massachusetts, the incidence of syphilis is estimated to be 10,000 cases a year. The probability of a given Massachusetts worker having this disease within the year is about one in two hundred. Bismuth is not used as widely today as heretofore, many patients with syphilis being given penicillin instead. When bismuth injections are employed, the treatments commonly last for 10 weeks. It is probable that bismuth excretion after an additional 10 weeks is relatively slight.

Hence, the probability of a given urine sample being contaminated with bismuth, due to intramuscular treatment with this metal, can be estimated as not in excess of one in five hundred in this Commonwealth. Other sections of the country may be more or less fortunate. It is our opinion that such an incidence of contamination does not warrant extensive modification of the routine lead in urine procedure. In most cases where the value obtained for a single urine sample is of major importance, a medical follow-up should include interrogation as to any bismuth treatment so as to permit the necessary interpretations to be made.

Preparation of Known Concentrations of Gases and Vapors in Air

ALFRED N. SETTERLIND, Division of Laboratories
Illinois Department of Public Health

THE industrial hygienist must frequently prepare mixtures of known concentrations of gases and vapors in air. Indicating instruments must be repeatedly calibrated, absorption efficiencies determined for a variety of collection devices and for reagents when new chemical methods are to be evaluated. When high concentrations are desired, the preparation of such mixtures does not present important difficulties. Unfortunately, however, the need for concentrations below 10 PPM is not infrequent. This is illustrated by the fact that the list of MAC values adopted by the American Conference of Governmental Industrial Hygienists in 1952 contains 121 gases and vapors, of which 77 have MAC values at or below 100 PPM, including 32 having values at or below 10 PPM.

In preparing known mixtures two major procedures are available, the "dynamic" method, and the "static" method. In the "dynamic" method the dilution is achieved by feeding the gas or vapor at a controlled rate into a gas mixing chamber through which air is passed, also at a controlled rate. If greater dilution is needed than can be achieved by the proportioning device, a portion of this mixture is fed into another mixing chamber through which air is flowing, the rates of flow being closely controlled. Since this method of mixing may be repeatedly extended, there is, theoretically, no limit to the dilution which can be obtained. It is obvious, however, that the higher the dilution desired, the more complicated becomes the equipment. Moreover, when attempting to prepare vapor mixtures, means must be provided to generate vapors at a controlled rate, usually by evaporation, which further complicates the equipment. The main advantage of the method is that it provides a continuous and abundant supply of test mixture. It is therefore preferred in large scale experiments involving exposure chambers for toxicological studies.

The major need of the industrial hygienist for checking instruments or methods is a limited quantity of gas or vapor mixture, but so prepared that its concentration can be predicted with certainty. For this reason the "static" method of introducing a known quantity of gas or vapor into a vessel of known volume and, after thorough mixing, withdrawing a portion of the mixture is the favored one. The ideal equipment from the theoretical and operating standpoint would be gas holders of adequate volume to take care of any needed quantity in the laboratory. However, several unfavorable factors have prevented their general use. High fabricating cost and the limitation imposed by the presence of a liquid seal are probably the most important.

The usual procedure is to prepare the gas or vapor in a large glass bottle, from which a quantity of the mixture may be withdrawn. This equipment is readily obtainable, inexpensive, and, in general, chemically inert. By proper technique accurate concentrations are fairly easily prepared. There is, however, one serious limitation. The mixture taken out of the bottle must be displaced by some medium, and, since most gases and vapors at low concentrations either react with or are partly soluble in water and other liquids, the common practice is to use air for displacement, causing a continuous lowering of concentration. Therefore only a small portion of the total supply can be used, and this portion is often insufficient.

The theoretical change in concentration due to withdrawal of a quantity of mixture, its replacement with air and some

experimental applications using one glass bottle have been previously described.[1]

The theory is based upon the assumption that when a portion is withdrawn the incoming air is instantaneously mixed with the remaining contents. If for an experiment, we want to keep the concentration from dropping below 90.48% of the original, the average concentration of the withdrawn portion would be 95.24% (See Table I). The *maximum possible* error due to dilution is then 4.76%, a not unreasonable requirement.

In such a case only 10% of the bottle volume may be used. This serious limitation is fairly well recognized. Less well recognized, however, is the fact that this limitation can to a large extent be overcome by preparing the mixture in two or more series connected bottles. Thus when mixture is withdrawn from the last bottle it is not displaced by air, but by mixture from the preceding bottle. Taking the previous example requiring an average concentration of not less than 95.24% in the withdrawn volume: using one bottle the amount available is 10%, using five bottles the amount is 300% of a single bottle volume. *By increasing the total volume five times, the amount available for the test is increased 30 times.*

For the convenience of the reader the residual concentration as well as the average concentration withdrawn is calculated in steps up to 500% of a single bottle volume for one or any combination up to five bottles in series. These data are given in Table I.

In this arrangement outside air enters the train through bottle No. 1. For those who desire to calculate intermediate values or residual concentration when more

[1] FRANK M. STEAD and GEORGE J. TAYLOR: "Calibration of Field Equipment from Air Vapor Mixtures in a Five-Gallon Bottle." *J. Indust. Hyg. & Tax.*, November, 1947.

TABLE I.

Average concentration of portion *withdrawn* and residual concentration of each of five series connected bottles. All bottles have equal volume and contain equal concentrations at the start.

Residual and average concentrations are given in percent of original.

First bottle is the one into which outside air enters.

Amount Withdrawn in % of Single Bottle Volume	1st Bottle		2nd Bottle		3rd Bottle		4th Bottle		5th Bottle	
	Residual Conc.	Average Conc. of Vol. Withdrawn	Residual Conc.	Average Conc. of Vol. Withdrawn	Residual Conc.	Average Conc. of Vol. Withdrawn	Residual Conc.	Average Conc. of Vol. Withdrawn	Residual Conc.	Average Conc. of Vol. Withdrawn
0	100.00	100.00	100.00	100.00	100.00	100.00	100.000	100.000	100.000	100.0000
10	90.48	95.24	99.53	99.76	99.98	99.99	99.997	99.998	99.997	99.9985
20	81.87	90.78	98.25	99.26	99.88	99.95	99.995	99.997	99.993	99.997
40	67.03	82.69	93.85	97.59	99.21	99.74	99.922	99.977	99.98	99.991
60	54.88	75.57	87.81	95.24	97.69	99.28	99.66	99.912	99.96	99.984
80	44.93	69.29	80.88	92.45	95.26	98.20	99.09	99.76	99.85	99.961
100	36.79	63.73	73.58	89.35	91.97	97.22	98.11	99.51	99.62	99.91
120	30.12	58.80	66.26	86.06	87.95	95.95	96.62	99.13	99.23	99.81
140	24.66	54.42	59.18	82.72	83.35	94.42	94.62	98.59	98.57	99.68
160	20.19	50.52	52.49	79.36	78.34	92.68	92.13	97.91	97.64	99.41
180	16.53	47.03	46.28	76.04	73.06	90.76	89.13	97.07	96.36	99.18
200	13.53	43.91	40.59	72.79	67.65	88.83	85.64	96.07	94.71	98.79
220	11.08	41.11	35.46	69.66	62.27	86.51	81.85	94.92	92.66	98.31
240	9.07	38.58	30.84	66.64	56.96	84.25	77.86	93.60	90.40	97.71
260	7.43	36.30	26.75	63.76	51.86	81.95	73.62	92.24	87.77	97.04
280	6.08	34.24	23.10	61.02	46.94	79.61	69.18	90.72	84.76	96.24
300	4.98	32.36	19.92	58.41	42.33	77.38	64.74	89.12	81.55	95.35
320	4.08	30.67	17.14	55.95	38.03	75.06	60.30	87.44	78.13	94.36
340	3.34	29.11	14.70	53.63	34.00	72.80	55.86	85.70	74.48	93.27
360	2.73	27.69	12.56	51.44	30.25	70.52	51.48	83.91	70.58	92.10
380	2.24	26.39	10.72	49.37	26.92	68.32	47.41	82.09	66.87	90.85
400	1.83	25.20	9.15	47.43	23.82	66.19	43.35	80.24	62.82	89.53
420	1.50	24.13	7.80	45.63	21.03	64.12	39.55	78.38	59.00	88.15
440	1.23	23.09	6.64	43.91	18.55	62.12	36.01	76.54	55.22	86.73
460	1.005	22.15	5.63	42.29	16.26	60.19	32.56	74.70	51.31	85.31
480	0.82	21.28	4.76	40.76	14.20	58.34	29.32	72.88	47.45	83.76
500	0.67	20.48	4.02	39.33	12.40	56.55	26.35	71.09	43.80	82.22

than five bottles are used, the following formulas may be used:

For one bottle

$$C_1 = \frac{C_o}{e^{\left(\frac{V}{V_o}\right)}}$$

For two bottles

$$C_2 = \frac{C_o}{e^{\left(\frac{V}{V_o}\right)}} \left[1 + \frac{1}{1}\left(\frac{V}{V_o}\right)\right]$$

For three bottles

$$C_3 = \frac{C_o}{e^{\left(\frac{V}{V_o}\right)}} \left[1 + \frac{1}{1}\left(\frac{V}{V_o}\right) + \frac{1}{1x2}\left(\frac{V}{V_o}\right)^2\right]$$

For n bottles

$$C_n = \frac{C_o}{e^{\left(\frac{V}{V_o}\right)}} \left[1 + \frac{1}{1}\left(\frac{V}{V_o}\right) + \frac{1}{1x2}\left(\frac{V}{V_o}\right)^2 + \frac{1}{1x2x3}\left(\frac{V}{V_o}\right)^3 + \ldots\ldots + \frac{1}{1x2x3x\ldots x(n-1)}\left(\frac{V}{V_o}\right)^{n-1}\right]$$

where,

C_o = the original concentration

C_n = the residual concentration in the n^{th} bottle

V_o = the volume of the bottle in liters

V = the volume withdrawn in liters

e = 2.71828183

log e = 0.43429448

The plotted values of the numerical tables appear in Figs. 1 and 2. The residual concentrations in Fig. 1 have been plotted on semi-logarithmic scale, but the average concentrations of the volume withdrawn, Fig. 2, have been plotted on an arithmetic scale to avoid crowding at the higher concentrations.

The chief advantage of the table is that it enables the experimenter to determine readily the minimum number of bottles needed to produce a required volume of test mixture having a concentration within specified limits.

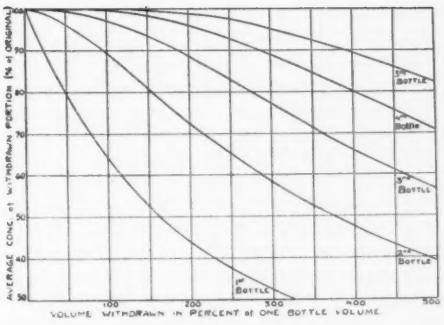


Fig. 1.

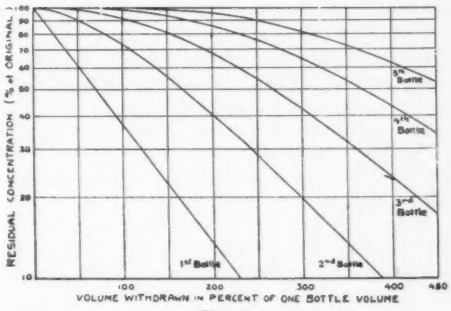


Fig. 2.

Selection of Bottles

FOR obvious reasons the use of the largest size bottle obtainable is most desirable. Not only does it insure an adequate supply of mixture, but also it increases the possibility of being able to prepare low concentrations without aliquoting. The practical limit for direct preparation of a mixture of gases depends upon the means available for accurate volume measurements. With vapors, the percent error introduced by weighing very small amounts of liquid, allowing a variation of 0.2 mg., becomes too dominant for reliable work. In such cases, it is more practical to prepare a relatively high concentration in a smaller bottle than draw off an aliquot for final mixing in a large bottle. We successfully used five-gallon bottles for many years, but since 13-gallon bottles became available we have found them more advantageous.

The calculated values were obtained under the assumption that the *bottles used are of equal volume, contain the same concentration,* and the *displacing gas volume instan-*

taneously mixes with the gas upon entering the bottle. The latter condition of course never exists and for most practical purposes this is rather an advantage as will be shown later.

Preparation of Mixtures

SINCE it is desirable to be able to prepare reproducible mixtures with a high degree of accuracy, a consideration of that subject is in order.

Several methods of introducing gases or vapors into bottles have been proposed and used. With regard to gases, the procedures are not too difficult. The preparation of vapor mixtures at low concentrations presents numerous problems. Some investigators weigh a portion of solvent in a small wash bottle type absorber, connect it to a partially evacuated bottle, allow a small amount of air to pass through the absorber and determine the amount evaporated by loss in weight. With this procedure it is practically impossible to obtain the desired concentration. Furthermore, the errors due to loss of vapors in connection tubing and the impossibility of estimating the change in buoyancy of air displaced by vapor when filling the absorber makes the calculation of the amount introduced subject to gross errors. Evaporating all of the solvent in the absorber is a somewhat better method, but still suitable only for very high concentrations. The same and even more serious objections may be made against the practice of introducing a measured volume of solvent directly into the bottle and calculating the concentration.

For the most accurate result when preparing vapor mixtures, the required amount of solvent should be weighed in a small glass ampoule which subsequently is introduced either directly into the bottle or into a separate smaller container connected to the bottle. After partial evacuation of the system, the ampoule is crushed and incoming air evaporates the solvent. The small volume of the ampoule precludes any significant error due to buoyancy of the air. The ampoule technique also offers the advantage that water soluble gases, such as HCl, H_2S, SO_2 etc., may be introduced in the form of a solution and totally evaporated using dry air, taking care, of course, that the amount of water does not exceed the quantity required for saturation of air.

Ampoule Making

THE making of ampoules is not difficult once the technique has been mastered, since it is neither necessary nor desirable to produce ampoules of uniform size or shape. It has been our practice to prepare a large stock containing different sizes, thus giving a choice of selecting the one suitable for holding the quantity desired. Using lime glass tubing of 4.0-4.5 mm. OD, an ampoule of about 10 to 15 mm. diameter is the most satisfactory. Smaller ampoules have been used, but in general they have heavier walls and are more difficult to crush. A suggested method for making ampoules is illustrated in Fig. 3.

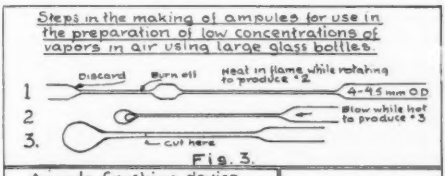
Ampoule Filling

IN THE preparation of a series-connected set of bottles, the question arises which is preferable: to prepare each bottle individually, or all the bottles in one operation? Because of the size of the bottles used, we prefer the former procedure. However, it has come to my attention that at least one experimenter, using a permanent arrangement of four stainless steel tanks, connects the crusher to a manifold from which the vapors are distributed equally into the tanks.[2] Obviously, only one ampoule need be prepared, containing four times the requirement for individual preparations, a distinct advantage at very low concentrations. The design of the manifold should, of course, be such that it insures even distribution.

Since filling the ampoules with the desired amount of liquid is most important, and sometimes difficult without practice, the technique successfully used in our laboratory will be described.

A number of ampoules are heated gently over a flame, placed on a numbered spot plate in a desiccator, and, after cooling, weighed. A small amount of solvent is placed in a petit cup or vial cap. The ampoule is picked up by tweezers made by bending a thin metal strip in the shape of a "U." Hollow depressions in the tips aid in holding the ampoule by the bulb. The bulb is warmed gently over a flame and the

[2]Private Communication, J. T. SIEDLECKI, Zurich-American Insurance Companies.


Steps in the making of ampoules for use in the preparation of low concentrations of vapors in air using large glass bottles.
Discard
Burn off
Heat in flame while rotating to produce *2
4-4.5 mm OD
Blow while hot to produce *3
cut here
1
2
3.
Fig. 3.

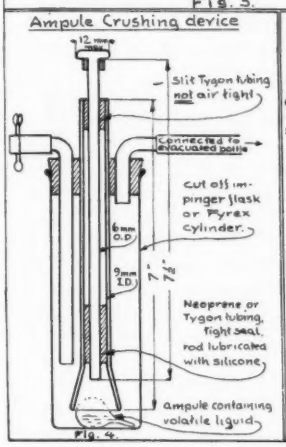


Fig. 4.

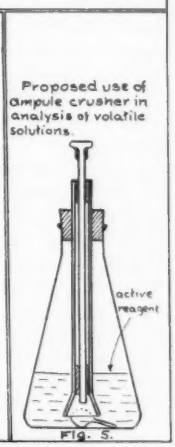


Fig. 5.

tip quickly inserted into the solvent. Upon cooling, solvent is drawn into the bulb. Experience will teach the right amount of heat required—if too hot, the liquid will rush in and fill the entire bulb, if still hotter, the incoming liquid will gasify upon contact with the hot walls and expel a portion drawn in. One soon learns to apply the proper amount of heat and to judge approximately when the desired amount of liquid has entered the bulb. At this point the ampoule is withdrawn and placed tip up on a support on the balance pan for preliminary weighing. If less than the desired amount is present, all the liquid in the bulb should be expelled and the procedure repeated. Excess solvent is expelled in small portions by turning the ampoule upside down and warming the bulb with the fingers. The tip is then touched with a piece of filter paper to absorb the drop. With experience one learns to estimate the approximate weight corresponding to the size of the drops formed. After the last expulsion, the weight should be about 0.5 mg. more than desired. At this point no liquid should remain in the stem. If it does, it can usually be brought down by chilling. The tip is sealed by inserting it at the hot edge of a Bunsen flame. After the seal is inspected through a magnifier to ascertain that no channel remains in it, the ampoule is placed in a desiccator and the final weight determined after cooling. With a little practice it is not difficult to fill any needed number of ampoules containing an amount which differs not more than 0.2 mg.

Ampoule Crushing

AFTER trying several methods of ampoule crushing inside the bottle, an outside crushing device, which permitted acceleration of evaporation by heating was found most practical. A suggested design for the device appears in Fig. 4. The dimensions are not critical and its operation is self-explanatory. An important feature is to be sure to provide a channel in the top seal of the rod. If not provided, a vacuum may be created between the top and bottom seal if the lower seal is not air tight. As a result when the ampoule is crushed some vapor or liquid may be lost by leaking into the space between the seals. If the top seal is channeled a small leak in the lower seal does no harm. Also if the lower seal is not a very tight fit, it may be desirable to place a temporary stop, such as a split cork, above the top seal to prevent the rod from sliding down and prematurely crushing the ampoule when vacuum is applied. To prevent accidental puncturing of the bottom of the container, a stop should be provided.

Fig. 5 depicts the use of the ampoule crusher on those occasions when it is desirable to analyze the strength of solutions to be used in the preparation of ampoules.

Filling of Bottles

THE inlet and outlet of the bottles are made of glass tubing of not less than 10 mm. OD, passing through a neoprene stopper. The outlet should extend just below the underside of the stopper, but the inlet tubing should extend about three-fourths of the distance to the bottom. Furthermore, it should be bent in such a manner that the air stream enters in a tangential direction slightly inclining toward the bottom. In this way, the inrushing air will set up a turbulent vortex, insuring thorough mixing. Experiments convinced us that whereas a

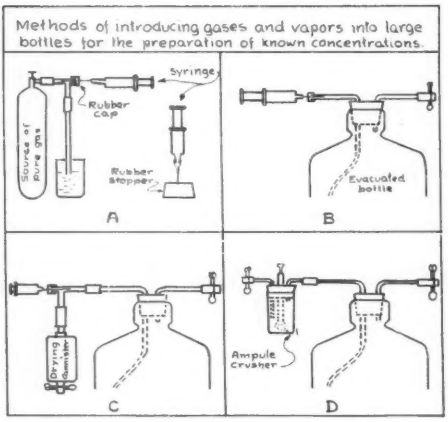


Fig. 6.

bottle having a straight vertical inlet required a circulation pump for mixing, the design described above made the pump unnecessary. The connections between the bottles should, of course, be made with a minimum of rubber tubing.

For preparing gas mixtures, the method depicted in Fig. 6A has been found both convenient and economical on the gas supply. It consists of a glass "T" tube with one end of the cross arm connected to the gas supply, the other end cut off about a half-inch from the stem and stoppered with a skirt type rubber stopper. The stem is connected to a piece of glass tubing, the other end of which is submerged in water. Before sampling, the system is flushed to expel air, then the flow of gas is adjusted to bubble slowly. Selecting the smallest size syringe suitable for taking the sample, the needle is inserted through the stopper until the tip reaches beyond the "T." The syringe is filled, withdrawn, and the gas expelled. This procedure is repeated two or three times. Finally an amount of gas slightly in excess of that needed is withdrawn, then the point of the needle is stuck into a rubber stopper. The plunger is pressed momentarily to be sure the gas is left under slight pressure. For obvious reasons the foregoing operations should be conducted under a ventilated hood. The syringe with its content is left near the bottles to attain room temperature.

The inlet of the bottle system is closed with a skirt type rubber stopper and evacuated to not lower than 15 inches of mercury. It is best to have a vacuum gauge connected to the line. *Complete evacuation is neither necessary nor desirable since in at least one instance known to the writer, it has caused a bottle to implode.* However, we used a vacuum of 15 inches of mercury for numerous experiments during the past 12 years without an accident.

After about five minutes, the syringe is removed from the stopper, the excess gas expelled and the needle inserted through the rubber stopper on the bottle, Fig. 6B. (If the syringe is held by the needle, heat from the hands will not alter the volume.) The vacuum will immediately draw the plunger into the barrel. After withdrawing the syringe, the stopper is removed from the bottle inlet. Air will rush in with considerable speed, and, owing to the shape of the inlet tubing, set up a turbulence which insures mixing without extraneous aid.

If it is desirable to mix the gas with dry air, the arrangement illustrated in Fig. 6C is suggested. Since only partial vacuum is used, it is necessary to have the air pass through the drying canister while purging the bottle prior to preparing the mixture.

The method of preparing vapor mixtures is illustrated in Fig. 6D. In general it is advantageous to warm the bottom of the crusher with a flame until it feels fairly hot. After crushing, the pinchcock is opened momentarily at intervals until no droplets or sign of liquid remain visible within the crusher. Any liquid trapped in the ampoule stem may be liberated by additional heat or by crushing it. The pinchcock is then opened fully until pressure equilibrium is established. By following this procedure, most of the sample will be transferred before too great a pressure change has occurred, thus insuring a thorough mixing of vapors and air by turbulance.

Purging Bottles

THE complete removal of a gas or vapor from a bottle in preparation for a fresh mixture is not always as rapid as one would like. The method which requires least attention is to connect each bottle to a vacuum or pressure line and purge it with a stream of air. The speed with which this can be accomplished depends upon the air supply.

Knowing the capacity of the pump, the minimum time for purging can be calculated from the tables given. An alternate method is to remove the gas mixture in 50% increments by repeatedly evacuating the bottles to 15 inches of mercury; then releasing the pressure. In either case it is necessary to remove from five to 10 bottle volumes.

Calibration Curves

A MAJOR reason for the preparation of gas or vapor mixtures is the calibration of instruments. Usually we prepare three or four different concentrations within the range of the instrument to establish a curve. In order to minimize any possible error from residual concentrations, we prepare the lower concentrations first. Originally, these concentrations turned out to be lower than expected. Presumably this was due to adsorption of gas or vapor on the walls of the container. We then adopted the practice of pre-conditioning the bottles by discarding the first batch of any gas mixture, purging the system, and then preparing the desired concentrations. In this way the variability of the first preparation was lessened.

Experimental Results

IN ORDER to ascertain the advantage of using series-connected bottles, a number of runs were made with different instruments, such as, the Carbon Monoxide Indicator, Benzol Indicator, and the General Electric Mercury Vapor Detector. In all these experiments a set of five bottles was used. Since the mercury vapor detector has a very rapid response, it should best illustrate the performance of the bottle technique. The curves B and C illustrated in Fig. 7 represent the response of that instrument to pyridine in air. Pyridine was selected in preference to mercury since accurate vapor mixtures could be more conveniently prepared. The instrument was first calibrated against concentrations of 150, 300, 600, and 1250 PPM. The calibration revealed the most sensitive response occurred in the region from 0 to 600 PPM. For the performance tests a concentration of 450 PPM was used.

One difficulty revealed in preliminary tests was that of measuring the air flow.

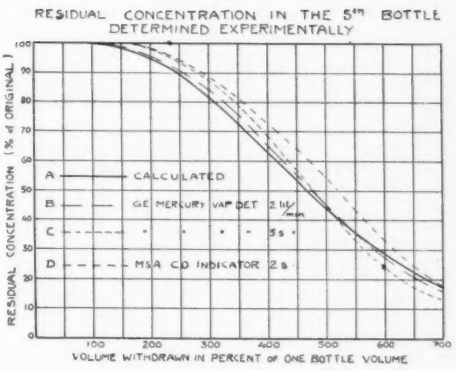

RESIDUAL CONCENTRATION IN THE 5TH BOTTLE DETERMINED EXPERIMENTALLY
RESIDUAL CONCENTRATION (% of ORIGINAL)
A CALCULATED
B GE MERCURY VAP DET 2 lit/min
C " " " 5 "
D MSA CO INDICATOR 2.8 "
VOLUME WITHDRAWN IN PERCENT OF ONE BOTTLE VOLUME

Fig. 7.

Normally, the instrument samples at a rate of approximately 5.5 liters/minute by means of a blower fan. This rate was impossible to maintain due to the flowmeter and tubing in the system. By using air under pressure and introducing it at a metered rate into the first bottle, this difficulty was overcome. For convenience the rate chosen was 2 liters/minute. During the test run the instrument blower was not in operation. Thus an even air flow was produced, but, most important of all, the absorption chamber was under positive pressure instead of negative, thereby insuring that no dilution could occur in case of possible air leak in the chamber. At intervals of four or five minutes the air flow was interrupted, the instrument purged, and the meter readings checked for balance and sensitivity. The readings used in plotting the subsequent curves were obtained immediately before the checking procedure.

Fig. 7 shows the comparison between the residual concentrations of pyridine samples at a rate of 2 liters/minute (Curve B) and that of the theoretical concentration (Curve A). A second test with pyridine, conducted in an identical manner, using a rate of 5.5 liters/minute is plotted as Curve C. This shows considerably greater divergence from the theoretical than curve B, and is undoubtedly due to less efficient mixing (per unit of time) when the higher rate is applied.

The fourth curve, D, depicts the performance of a mixture of carbon monoxide as determined with the MSA Carbon Monoxide Indicator using the air flow of 2.8 liters/

minute maintained by the instrument pump. In this case the deviation is due to the lag in response of the thermo-electrical circuit and the presence of the drying canister, in addition to imperfect mixing in the bottles.

Comment

THESE curves illustrate one important point in the use of this particular adaptation of the "static" method. Since the drop in concentration at the beginning of withdrawal will never occur sooner than anticipated, one can be sure that *if the portion withdrawn has been selected to maintain a concentration above a certain limit, that condition will be fulfilled.*

Agreement between the experimental and theoretical curves requires two major conditions: that the mixing of the incoming air or gas mixture with the residual closely approaches the instantaneous mixing assumed in the derivation of the equations, and that the response of the instrument to the concentration be very rapid. Few of the instruments in present use exhibit such rapid response. Some lag owing to characteristics of the detection device; others have incorporated in their design auxiliary features such as canisters or surge tanks, which for a time modify the concentration of the incoming mixture until a maximum is reached. Consequently providing a mechanical stirring device would not constitute a significant improvement along these lines.

With regard to the calibration of instruments, one could conceivably produce a calibration curve from one prepared mixture. However, since most instruments lack instantaneous response and do not faithfully follow the theoretical curve, it would be necessary to prepare a performance curve for each instrument under strict experimental conditions making sure that the curve could be closely reproduced. It is doubtful that such a procedure would effect any saving of time or effort in comparison with the preparation of mixtures of different concentrations needed to calibrate the instrument in the conventional way.

Donora and London

THE PUBLIC mind—not too ratiocinative—still associates the Donora episode of 1948 with fortuitous and possibly mischievous conditions at the time, in one large-scale industrial establishment. The official report properly attaches greater significance to an unusual meteorologic condition—atmospheric inversion. The inversion was created by nature, but the disturbing contaminants were man-made. In the period from December 5 through December 8, 1952, London, England, suffered from one of its worst fogs. The death rate mounted tremendously. The official report recently made available and widely publicized (*U.S. Public Health Reports*, Volume 68, May, 1953) goes far in further clarification of what must have occurred at Donora. The onset of the fog "was determined by the meteorological factors of almost complete absence of wind or air movement and low temperature, which produced what is technically described as an 'inversion' whereby the normal upward air circulation by convection currents was arrested. Hence at ground level and for many feet above, there was no air movement, and smoke, sulfur oxides, and other air contaminants increased to concentrations much above those normal for the winter season." During the week ending December 13, the total number of deaths in London County was 2,484. The death rate per million of population was 745, whereas the expectable deaths for the period in season were only 300 per million. Thus the anticipatable deaths were 990, while the actual number was 2,848. On referring to the death certificate registration as to causes of death, tuberculosis, heart disease, hypertension, pneumonia, and bronchitis well contribute to the excess over normal. In the week ending November 22, at a time long before the disastrous fog, the registered number of deaths from bronchitis was 46. For the week ending December 13, the number was 704, and in the following week 396. The import of the disaster is reflected in the statement that the death rate was as great as that during the worst week of London's last cholera epidemic.

A CRITICAL EXAMINATION OF

Air Sampling Instrumentation, Methods

WILLIAM T. INGRAM, Associate Professor of Public Health and Engineering
Executive Secretary, Air and Water Pollution Research Section
New York University, College of Engineering, Research Division
LAWRENCE F. DIERINGER, Instructor in Industrial Hygiene
New York University, Institute of Industrial Medicine

INSTRUMENTATION development applicable to collection and measurement of atmospheric pollutants is in a dynamic state at the present time. During the first 40 years of this century the collection of air samples was, in general, a matter of ultimate necessity rather than scientific exploration.

Advances in scientific collection and analysis were associated with a few major incidents associated with emissions from smelters. Ducktown, Tennessee; Anaconda, Montana; Trail, British Columbia and Selby, California, are familiar citations for early investigations. Studies were conducted to establish information relating specific suspected point sources to observed effects and possibly to quiet the fears of an uneasy but somewhat localized group population. Gross pollution of the air of an area was established by measurements that needed no great refinement. Correlated air movement and meteorology were of minor concern in early studies and actually were first thoroughly investigated at Trail by methods then current.

Within the past 20 years conditions long known and combated in England have become the concern of urban groups. In St. Louis, Pittsburgh and New York smoke or sootfall surveys were conducted to support the obvious. Soot soiled buildings, filtered into houses, and dirtied the drapes and furnishings. Even a well laundered shirt could not survive a day in the city.

In the immediate 10-year period we have all witnessed an increased interest in the preservation of clean air. A movement toward conservation of this natural resource, air, is in progress.

Many parallels to a national campaign for the control of water pollution can be noted as cities, counties, states, and industries face the problems of atmospheric pollution and engage in scientific studies and carry on positive action programs.

This presentation is directed to a critical review of instrumentation and sampling methodology, influenced in its development by the technological boundaries of the times and the purposes for which air sampling was required.

Presented at Joint Session of the Engineering and Air Pollution Sections, AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, at Los Angeles, April 23, 1953.

Methods Classified

THE authors, while studying some 400 published references, have found it convenient to classify air sampling methods into those applicable to five major groups of substances: particulate matter, inorganic metals and salts, inorganic gases, organic substances, and miscellaneous mixed substances. It is obvious that these groupings do overlap. For example, particulate matter may comprise solids that are organic or inorganic; however, the purpose of sampling may be that of measuring particulate matter, and the surveyor is not at the moment concerned with chemical classifications or specific identifications of that solid matter. Hence the purpose of sampling has influenced our classifications just as it has influenced the choice of instruments for collection and measurement of pollutants.

PARTICULATE MATTER: One of the earlier methods for ascertaining the weight of solid matter in air is discussed by Cohen.[1] He drew a sample of air through a tube containing a cotton-wool plug. The tube

was connected to an empty bottle and a water-jet aspirator. The aspirated air was measured in a gas meter. The weight of matter was expressed in milligrams per 100 cubic feet of air.

A deposit soot gauge comprising a wide funnel leading through a narrow tube to a glass bottle and collecting both deposited matter and water was used in London soot-fall studies in 1910 and 1911.[2]

Kershaw[3] in 1913 reviewed several methods developed by Rubner, Renk, Hahn, Cohen, Lietmann, and Fyfe and entered a plea for uniformity and standard methods for the collection and measurement of dust-fall. His plea was little different from the one we hear frequently today. The methods should (1) measure the actual amount of suspended matter in the air, and (2) permit collection in a way that would permit analysis. The method offered was one involving an instrument consisting of a circular open-topped gauge vessel constructed of enamelled cast iron. Material settled and was washed by rainfall into a glass bottle. Analysis consisted of drying, and weighing the bottle content.

Another type collector was used to determine dustfall from a cement plant in California. Glass plates coated with vaseline were placed in various locations. After exposure the plates were cleaned in gasoline. The dustfall was measured by filtration.[4]

The use of directional sampling equipment is reported in connection with a Chicago study in 1915.[5] A cotton filter holder was held facing the wind by a vane. Filtered material was weighed and also examined microscopically.

Variations, modifications and innovations of these early instruments and techniques are reported by others. Hill[6] after trying several methods in an effort to find a standard concluded in 1917 that with any method of dust determination the results are relative only and cannot be absolute, since minute dust particles present are not caught.

Impingement methods were being developed in England, and the Advisory Committee on Air Pollution[7] in 1921 and Owens[8] in 1922 reported the use of high velocity air jets against a glass slide. Condensation of atmospheric moisture due to pressure reduction aided adherence of dust. The water evaporated leaving the dust behind. Dust counts, microscopic examination, and micro-chemical analyses were considered feasible.

Owens[8] developed an automatic filter recorder for use in measuring smoke pollution in city air. Two liters of air were aspirated through filter paper discs placed on the periphery of a large revolving disc. A clock mechanism positioned new filter paper over the aspirator device at intervals. Thus a 24-hour sampling schedule could be maintained, and the spots of black could be compared by shades. Owens compared the shades with samples taken in his jet dust counter and derived calibrations in terms of particles per milliliter and milligrams per cubic meter. For London air 10,000 particles per ml. were equivalent to 1 milligram per cubic meter. The limitation on the method was the color of the filter collected matter. Unless the shades were black, the relationship did not hold.

Sampling at various heights above ground in an airplane was tried in the Washington, D.C., surveys of 1922-23 and 1923-24.[9] A modified Owens jet dust counter pumping at five times capacity and provided with duplicate heads in which cover glasses were secured made it possible to take samples from the planes at different elevations.

Greenburg[10] pointed out errors in sampling and analysis occurring when the Owens counter is used. A dense dust ribbon is not accurately counted under the microscope. Dust sedimentation samples involve an increment of time and hence do not give accurate measure of the actual dust in a given air volume in place.

Paper thimbles were used in the Salt Lake City studies reported by Monett, et al,[11] in 1926. Such study requires aspirating equipment and time. The weight of material in a measured volume of air is known, but little information about the character of the solid material is obtained.

A number of testing methods used on controlled air in stacks, workrooms and other inside places were developed following World War I. These include filtration, centrifugal separation, electrostatic precipitation, and impingement. Long-time slow rate sampling and short-time high rate sampling were both usable under certain

conditions and for certain purposes, but none could be considered as a standard method for the collection of outside air. The Greenburg-Smith impinger was found by Stern[12] to be efficient in the collection of a complete sample for chemical and physical analysis. However, the air that was collected was still a cross-section of atmosphere at the collection intake over a time period.

It is worth noting that the spotlight seems to have left the study of sampling particulate matter in outdoor air in the 10 years following 1926. Collecting devices previously discussed were being used and modified. Bloomfield[13] using the Owens counter showed that outdoor air-borne particles were median size 0.5 micron while indoor air particles were median size 1.5 microns. Hazard and Drinker[14] impinged (at a velocity of 100-150 meters per second) air on a moving film strip coated with gelatin, glycerine, water mixture and recorded the density by using a photoelectric cell system as the strip sampling proceeded. Advantages were reported for permanent, long period recording and the opportunity to observe rapid changes in concentration of atmospheric dust.

Coste[15] supported the use of the Owens jet counter for the collection of finer solids and also included the thermal precipitator described by Whytlow-Gray and Green among the more efficient collecting methods.

Davidson and Master[16] changed the Owens automatic air filter so that a motor-driven pump and diaphragm gas meter measuring air volume replaced the water aspirator. A strip chart activated by a small synchronous motor provided a record of atmospheric dust at selected time intervals. The spots were compared with shade densities by a photoelectric scanning device calibrated to measure focused light penetrating the filter paper strip. This device was valuable in eliminating personal error. It provided an objective comparison with 20 density shades as they were interpreted by light penetration.

The Leicester, England survey[17] which ended in 1939 and required six (war) years to examine statistically probably offers the best available comprehensive proof of variability of results obtained with sootfall measurement devices. Differences were due to variations of wind direction, rainfall and other factors connected with weather.

Means of deposit gauge readings, over a long period, will show changes of atmospheric pollution emission satisfactorily, but, over a short interval, means will reflect mainly the changes in weather. The need for long time observations is emphasized in the 26th Report of the Department of Scientific and Industrial Research (England).[18] "It is well known that measurements of atmospheric pollution are sharply affected by the weather, and that large variations are therefore unavoidable, even in districts where the emission of pollution is most regular and uniform. The standard error is a measure of these unavoidable variations; when properly applied it is both a safeguard against the temptation to make too close comparisons and an assurance that the maximum information has been drawn from any given set of observations."

Sonkin[19] discussed his modification of the cascade impactor in 1946. The instrument was designed to measure concentrations and particle size of airborne liquid and solid particles. As the cross-sectional area of each succeeding jet decreases, the air velocity increases and progressively smaller size particles impact out of the air stream on slides. The instrument has been reported efficient as a sampling device for determination of aerosols of mass median diameter 0.25 micron. However, Magill[20] reported in connection with Los Angeles smog studies that the impactor was only highly efficient in collecting particles above one micron size.

Smoke and Soot: Rather unobjective methods of smoke density measurement such as the Ringlemann chart comparison and various instruments for matching color shades by observation leave room for further study. Such methods as are now used are subject to personal error and variation because of non-black color shades appearing as emissions from chimneys. Results can be considered only approximate and comparative at best.

Many of the methods already discussed are applicable in the measurement of smoke and soot as particulate matter. Sootfall measurements by deposit gauge methods have been used extensively in many cities of the United States and in England. Smoke filter methods as developed by Owens are

useful and samples can be studied objectively.

Hemeon[21] has recently developed an automatic smoke filter which aspirates air at the rate of 1/6 cfm through a one-inch diameter circle on filter paper tape. The tape, electrically controlled, shifts to the next position four times per day, and hence provides for a long time exposure of the filter paper to the sample air. Density evaluation of the spot can be obtained by density scale comparison, by optical evaluation, or relative light transmission methods. Chemical analysis of the material on the filter is also possible. The instrument has some similarity to Davidson's modification of the Owens filter but the design is simplified. Units can be placed at appropriate collecting stations without too great cost. Average conditions of atmospheric particulate matter content proposed by the British Department of Scientific and Industrial Research might be obtained and evaluated with due consideration of sampling errors.

Sulfuric Acid: Sulfuric acid content in outdoor air is difficult to determine with any degree of accuracy. Coste and Courtier[22] used a method that freed the air of sulfur dioxide, saturated the air with water vapor at room temperature, and passed the air through a flask immersed in an ice bath. Sulfuric acid nuclei formed droplets large enough to be retained in the flask. The droplets were titrated with N/250 potash in a microburette for quantitative determinations.

Owens[23] reported a sampling method using small porcelain cylinders coated with lead peroxide paste. The cylinders exposed for a month permitted a partial conversion of the peroxide to sulfate by the sulfur in air. The amount of sulfate formed was considered a measure of the activity of sulfur acids in the air.

After a period of use of the lead peroxide method (1934-44) the Department of Scientific and Industrial Research[18] was able to call attention to (1) a cyclic variation due to variation in the amount of coal burned, and (2) a cycle occasioned by the state of the exposed lead peroxide surface. The surface, more moist in the winter, is more reactive and hence yields more lead sulfate. The accuracy of the method is shown by the standard deviation of single observations. This is usually on the order of 5% whereas the deposit gauge sulfate standard deviation is on the order of 10%. This method should not be confused with methods for measuring sulfur dioxide concentration.

Small concentrations of sulfuric acid have been determined in Los Angeles by a method that collects mist on Whatman No. 4 filter paper from air samples of 50-60 cfm for a one-hour period.[24] The sample is titrated with 0.002N sodium hydroxide and acidity is measured with a pH meter. High collection efficiency and low resistance favor the high volume sampling rates and suggest reasonably accurate determination of hourly sample sulfuric acid content.

Summary Discussion of Particulate Matter Sampling: It is rather obvious that in some 50 years of study on collecting and sampling particulate matter as such, there has been only a small departure from the methods devised by early workers. This is indeed a tribute to those who recognized the principles of filtration, impingement, ionization, and sedimentation. The investigative effort of today is still being directed toward improvement of instrumentation employing those principles so that the efficiency of collection is higher and the labor of collection is less. Analytical procedures are being made more effective by incorporating photoelectric measuring devices. Continuity of sampling has been made easier by timing mechanisms. Some recognition has been given to errors introduced by local air turbulence, weather, and air movement. Long time studies tend to reduce the effect of errors, and by amassing enough data at particular sampling stations during extended study periods it becomes possible to draw statistically valid conclusions concerning changes.

It would be extremely difficult to substantiate the absolute values reported in individual samples taken with most of the instrumentation discussed. Rather, those values must be compared with others. After due consideration of the influence of pertinent conditions, a weighted observation of apparent values is calculated as the one least assailable on scientific grounds.

INORGANIC MATERIALS, METALS AND SALTS: The inorganic metals include a number to which only occasional attention

may be directed because they are associated with specific processes, are peculiar to a locality, or are rarely significant constituents of stack emissions. These metals may be metal salts, oxides, metal fumes, and metal dusts. Many of them, though rare in occurrence, are, nevertheless, highly toxic and even in rare amounts could conceivably be serious atmospheric pollutants. Beryllium, arsenic, antimony, selenium, cadmium, chromium, lead, mercury, and copper are always suspect.

It may be said generally that a method of collection is selected that will make available a quantity of the suspected metal in forms suitable to its analysis. If the material is in dust or aerosol form, one of several methods for collecting particulate matter will be chosen. The Greenburg-Smith impinger and the electrostatic precipitator have been chosen by many. However, studies by a committee of the American Conference of Governmental Industrial Hygienists[25] showed a variety of personal preferences on the part of industrial hygienists. Certainly there is no standardization on collection methods for obtaining any of the materials as dusts or fumes.

Reference to methods of collection and analysis used by field investigators will emphasize the variations. The Public Health Service used both standard impinger and electrostatic precipitator in collecting stack samples at Donora[26] to be used for determining antimony, lead, arsenic, and fluorides. Antimony samples were also collected in a Folin ammonia absorption bell fitted into a washing cylinder containing 10% mercuric chloride. Sampling rates of 3-6 liters per minute were used. Arsenic samples were collected in the bell fitted into a washing cylinder containing 20% silver nitrate solution; 3-6 liters per minute were collected.

Arsenic samples from smelter flue gases were taken by Harkins and Swain[27] in studying constituents of smelter smoke. Apparatus included a filter tube containing cotton supported on porcelain discs, three flasks with distilled water, two bottles with absorbent cotton, coiled copper tubing, a gas meter and manometer. Suspended matter was removed from the cotton by washing and combined with liquid in flasks.

Atmospheric samples were taken by Eisenbud and co-workers[28] in the vicinity of a plant producing beryllium compounds, by aspirating at a flow of 100 linear feet per minute through Whatman No. 41 filter paper. The samples thus taken were analyzed spectrographically. The same method was used under similar circumstances in Ohio.[29]

Samples for cadmium analysis were collected at Donora[26] with a portable electrostatic precipitator at a sampling rate of 3 cfm for a period of two hours. A glycerine manometer was used to control flow rate.

Chrome determinations were made on air samples collected in duplicate by aspiration of air through twin filter paper holders and air flow meters. Bourne and Rushin[30] reported sampling rates of 4 cfm through 5⅞ inch Eaton and Dikeman 623-026 filter paper. Control samples were taken upwind to permit comparison. Analysis was performed polargraphically.

Samples for copper and manganese dust were taken as settled dust samples in a ground level sampler near a coke plant.[31] A tilted tray permitted rain to wash the settled material into a glass collecting bottle.

Experimental work during the Donora investigation[26] led to certain modifications in the method of collecting samples for fluoride determination. Impinger samples through 0.1N sodium hydroxide were not considered sufficiently accurate, and fritted bubblers in parallel preceded by filter paper were used. The combination allowed determination of fluorides present in either particulate or gaseous state.

Medical Research Council[32] (England) investigators used a sampling apparatus comprising a No. 1 Whatman filter paper supported vertically, a glass bead bubbler containing about 30 ml of 50% ammonia solution and a compressed air operated injector fitted with a ball flow meter. The combination was developed to determine both gaseous and particulate fluorides that might affect people and animals in the vicinity of aluminum refining plants.

Los Angeles County Air Pollution Control District[33] has used a Milligan type bubbler containing 2% sodium hydroxide solution. A pump and flow meter, or a calibrated applicator bottle is used for taking a measured 30-90 liter sample.

One of the difficulties in studying gaseous

fluorides in atmosphere is occasioned by the quantity required for measurement and the time required to collect enough sample. Averages, rather than extremes of concentration, are indicated by sampling procedures previously discussed. The Stanford Research Institute has been searching for a more sensitive method and has reported in 1953[34] its developmental work on apparatus that would meet conditions of a reaction reported in *Analytica Chemica Acta*, a Holland publication. Filter paper is dipped into chloroform solution of a fluorescent metal salt of 8 hydroxyquinoline and the solvent evaporated. The metal oxinate remaining fluoresces under black light. The fluorescence is diminished by exposure of the paper to hydrogen fluoride gas. By having the paper in tape form, both time of occurrence and variation in fluorescence can be determined. Sensitivity is reported to be in the range of parts per billion. The actual field instrument is not yet completed.

Lead dust and fumes have been collected in dustfall collector units[31] (1932), by Greenburg-Smith impinger[35] (1933) and by electrostatic precipitator.[26] Lead free glass is used in sampling flasks. Sampling rates may be from 1-3 cfm.

Elemental sulfur has been determined in Los Angeles City air[36] by passing air through a filter paper impregnated with thallous sulfate. The paper, when dipped in dilute acid, produces a brown color that is measured colorimetrically against standards.

Total sulfur measurement after collection by passing through absorption trains is reported in two early investigations in the U.S. In the Chicago investigation[5] the train consisted of a cotton filter, a series of glass bubblers, with absorbing solutions, a gas meter and an air pump. In the Selby[37] investigation a sample of from 250 to 2800 liters of air taken at a rate of 1.3 liters per minute was aspirated through absorption solutions which oxidized (with iodine or bromine solution) and dissolved sulfur dioxide and absorbed the trioxide (0.2% sodium bicarbonate or dilute ammonia).

In the studies reported by Ives, et al[38] (1931-33), the Greenburg-Smith impinger was used. For seven hours an air sample, at a rate of 1 cfm, was collected in distilled water.

Thomas in 1943[39] reported a modification (a multiple port stop cock valve) of the automatic sampler which permitted determination of total volatile sulfur compound with the same precision and sensitivity as for sulfur dioxide analysis. The Public Health Service, using all glass impingers and a collecting medium of 50 ml of 0.005 N iodine with 0.5% sodium hydroxide diluted to 100 ml with distilled water,[26] collected samples for total sulfur analyses as for sulfur dioxide determinations.

Zinc fumes and dust have been collected successfully with the portable electrostatic precipitator at Donora.[26]

Summary Discussion of Inorganic Material Collection Methods: As was intimated at the beginning of this section, the methods presently used for the collection of inorganic materials have evolved from a long historical development of methods for the collection of particulate matter. One finds the same instruments, the electrostatic precipitator, the impinger, filter paper, and absorption trains used. The absorbant or the oxidant used to hold the material sought is selected for a particular sampling regimen. The weakness inherent in sampling periods of long duration persists. Some effort has been made to find testing procedures involving impregnated papers that deliver, in effect, spot samples. However, the analytical techniques that make such samples extremely useful have not reached their full measure of development, and still pose serious problems for the analyst and the researcher.

INORGANIC GASES AND ORGANIC MATERIAL: Methods used to take air samples containing gases have many limitations. The APHA Subcommittee on Chemical Methods in Air Analysis[40] in 1938-39 found that sampling devices fell into two groups; those indicating the presence of the contaminant, and those absorbing devices which collect the sample so that a determination may be made later.

It is usually necessary to test the efficiency of the samples, i.e., sample air containing known concentrations of the gas to be determined by analysis or compare results with another method tested.

Failure to absorb or trap in a single tube has led to the development of absorption trains, multiple impinger collectors, and

similar devices using one or more collecting media. In general the more soluble gases may be collected in commonly used absorbing agents such as sodium hydroxide, sulfuric acid, potassium iodide, or distilled water, provided the dispersing method is suitable for the particular gas. The APHA subcommittee prepared a fairly comprehensive list indicating those gases and vapors that could be collected in fritted glass bubblers, the Nichols absorber, or in impingers. These include ammonia, hydrochloric acid, hydrofluoric acid, nitric acid, carbon disulfide, and hydrogen cyanide. Less soluble gases requiring fritted glass bubblers in series include sulfur dioxide, hydrogen sulfide, carbon dioxide, chlorine, bromine, iodine, ozone, arsine, aniline, and phenol.

Some of the gases require extraordinary care and the employment of special sampling methods. Benzene, toluene and xylene should be absorbed in nitrating acid in a fritted glass Petri tube or in a glass bead or pearl column at very low flow rates (0.25 to 0.05 liters per minute).

Adsorption on solid surfaces has also been employed. Activated charcoal and silica gel are widely used, but do not have universal aplication; i.e., substances that hydrolyze readily may not be adsorbed.

Qualitative and semi-quantitative field measuring instruments employ the adsorption principle combined with a drying agent and an absorption agent or an idicator that will show the presence of the suspected gas. Instruments such as the carbon monoxide indicator may employ a catalyst. The heat generated is translated into a dial reading as PPM or % carbon monoxide present. It may be said generally that these instruments are of little value for measuring or indicating minute quantities of gases to be found in the outside atmosphere. They were developed more specifically for measuring high concentrations in closed working space.

The procedures for determining the more complex aldehydes, oxidants, petroleum vapors, and hydrocarbons, are more specialized and demanding than those for inorganic gases, and tax the ingenuity of the investigation staff. Reaction times may be slower. The substance may require more care in collection and more scrubbing, washing and oxidizing or reducing solutions to isolate it and prepare it for analysis.

Inorganic Gases Sampling: A few examples of practice are cited here to indicate sampling methods currently in use.

The Public Health Service, sampling for acid gases at Donora,[26] used standard impinger or bubblers, collecting in standard alkali solution.

In the New York City studies (1935-36) sampling methods included the Greenburg-Smith impinger collecting air in dilute sulfuric acid to determine ammonia concentration. The sampling rate was 1 cfm.

Stanford Research Institute studying Los Angeles air for presence of ammonia passed 50 cubic feet of air through a scrubber containing 0.1N sulfuric acid.[36] The method was reported accurate to 10% for measuring 0.01 PPM by volume.

Thomas[42] described the development of an automatic carbon dioxide recorder consisting of an air flow and measuring system, absorbers containing 0.005N sodium hydroxide solution, and a conductivity measuring system.

Carbon monoxide resulting from automobile exhaust gas emitted to the semi-closed condition of urban streets has been studied by many investigators. Henderson and Haggard reported a method in 1923[43] used in such studies. Samples were taken from a moving car. Air samples were pumped into basketball bladders and later transferred to glass or metal containers. A water filled jar was emptied and the displacing air was considered as a nearly instantaneous sample.

Bloomfield and Isbell[35] used "grab" samples taken by breaking the tip of an evacuated sealed 500-ml glass bulb to be analyzed in the laboratory.

Pincus and Stern[41] used a commercial carbon monoxide indicator of the catalytic combustion measururing type in New York City studies.

Nitrous acid samples were collected during Salt Lake City studies[11] in an absorbing bottle containing sodium hydroxide.

Nitrogen peroxide samples of London air were collected for three to 10 days at a time by passage through purified bacteriological wool packed in glass tubes and into bubblers containing sodium bicarbonate solution. Oxidation of nitrogen peroxide collected to ammonia permitted analysis.

Nitrogen oxide samples were taken at Donora[26] in four-liter bottles to which 20

ml of 0.1N sulfuric acid and five drops of 3% hydrogen peroxide were added immediately after collection. Shaking then caused absorption and oxidation of the oxides and allowed colorimetric analysis by the phenoldisulfonic acid method.

Stanford Research Institute collected samples in evacuated five-gallon bottles containing 0.1N potassium hydroxide and 0.5% hydrogen peroxide, and analyzed for the oxides by the phenoldisulfonic acid method. Magill[36] has reported that when 50 cubic feet of air is scrubbed in the presence of 50 ml of 5% sodium hydroxide solution, 0.05 PPM of nitrogen oxide can be measured with an accuracy of 10%.

Ozone was collected in samples of London air[44] by the device used for nitrogen peroxide, but the air was passed through chromic acid solutions to remove sulfur dioxide and split into equal streams. Half passed through a tower of fine crystals of copper sulfate and decomposed the ozone, but allowed the nitrogen peroxide to pass on through a scrubber containing potassium iodide solution in 0.01N sodium thiosulfate. Half passed directly through the latter scrubber and thus permitted measurement of the total ozone-nitrogen peroxide. Ozone was obtained by difference.

Sulfur Dioxide: Sulfur dioxide is a common air contaminant associated with coal burning equipment, smelter operations, and a number of chemical processes. Its importance was early recognized. On the determination of its presence and its concentration the outcome of legal cases rested.

In the Report of the Selby Smelter Commission[37] in 1915 a method of sampling sulfur dioxide in the air surrounding the plant is fully described. The sample was "instantaneous" in that less than 15 seconds was required for actual sampling. A volume of air, bringing pressure in an evacuated aspirator bottle to atmospheric, was exposed in the bottle to starch solution colored by iodine. A blank sample was run simultaneously. Sulfur dioxide in the sample was titrated with iodine in starch solution and a color comparison made between the colors of the sample and blank solution.

The Wells-Marston method used at Selby was modified in Salt Lake City studies[45] so that 100 ml of starch-iodide solution was introduced into an eight-liter bottle. The bottle was evacuated to a residual one-inch pressure. A sample from the upper strata of the bottle was then analyzed. The addition of iodine (the amount reduced by the sulfur dioxide present) produced a color matched with a blank. Swain[46] concluded that the method was accurate with a probable error of not over one part of sulfur dioxide in 10 million parts of air. By using a blank and back-titrating with sodium thiosulfate the method has been improved.

Thomas [47] was able to make an apparatus automatic to the point of titration by using two absorbers; one being charged automatically with fresh starch-iodide solution, while the other was being aspirated. In order to make the apparatus fully automatic Thomas and Abersold[48] suggested altering absorbant to slightly acidulated distilled water containing 0.003 to 0.006% hydrogen peroxide. Titration with alkali or by a conductivity method could be accomplished as a completely automatic procedure, and the accuracy was considered to be equal to that of the iodine method.

Smith and Friis[49] prepared an apparatus that they considered to be accurate and simple to operate. An impinger type absorption bottle, an orifice meter, regulating manifold and by-pass to a motor-driven vacuum pump was used to collect air samples in 0.1N sodium hydroxide. Titration against an iodine solution in the presence of starch determined the sulfur dioxide content.

The volumetric method[17] for measuring sulfur dioxide has been used in England since 1931. Fifty cubic feet of air per day are drawn through a bubbler containing 40 ml of dilute hydrogen peroxide. The sulfuric acid is then titrated with N/250 sodium hydroxide to pH 4.5. The method is conveniently combined with the Owens smoke filter for periodic measurement of municipal air pollution. Leicester survey studies indicated an average loss error of 0.005 PPM introduced by the combination sampling. Expressed as a percentage, the loss was estimated to be 4% at most. The volumetric method itself is considered to be accurate to 0.005 PPM, providing that the air does not contain ammonia or other acids.

Some sulfur dioxide measurement were made in Chicago.[50] This was done by absorbing a sample in slightly acidified dis-

tilled water containing 1 ml of 30% hydrogen peroxide, measuring the volume of sample collected, and titrating to neutrality with sodium hydroxide. Methyl red containing guinea green dye was used as the indicator.

Thomas, Ivie, and Fitt[51] reported an important change in the autometer in 1946. A continuous sample of air is pumped countercurrent to the flow of hydrogen peroxide-sulfuric acid solution in an absorbing column. The resulting change in electrolytic conductivity of the solution is determined by a conductivity cell and is recorded on a continuous chart as PPM sulfur dioxide. It has been determined that, when sampling at 15 to 18 liters per minute, efficiency varied from 95 to 98% for concentrations ranging from 24 to 2 PPM sulfur dioxide. This is true only when sulfur dioxide is the only soluble gas contributing to solution conductivity. Other gases, such as oxides of nitrogen, hydrochloric acid, hydogen sulfide, and ammonia will affect the readings.

Another fully automatic sulfur dioxide measuring instrument, the titrilog,[52] consists essentially of a chemical cell in which titration takes place between potassium bromide electrolyte and the air sample. Bromine produced is proportional to the output current of a D.C. amplifier and the concentration of bromine produces a voltage on the electrode connected to the D.C. amplifier input. When sulfur dioxide is present the bromine concentration is temporarily reduced. The record of current output with constant flow of sample will show sulfur dioxide concentration in relation to time. Sensitivity is reported to concentrations below 100 parts per billion. The instrument actually records sulfur dioxide, hydrogen sulfide, sulfides, disulfides and mercaptans that may be present. Titration time requires 15 to 30 seconds. The instrument is light weight and is not affected by temperature changes.

Organic Materials: Aldehydes in Los Angeles atmosphere have been collected by scrubbing 50 cubic feet of air in a scrubber containing 1% sodium bisulfite.[36] A double titration with iodine solution follows. One is performed before decomposition of the sulfur dioxide-aldehyde complex to remove excess bisulfite. The other is performed after decomposition of the complex by means of a buffer solution. The accuracy is questionable. The method measures 0.01 PPM aldehyde radical by weight within 50%. Formaldehyde sampling carried out by the Los Angeles Air Pollution Control District[33] was accomplished by bubbling air through a series of bubblers or by collecting in an evacuated bottle. Bubblers contained 1% phenylhydrazine hydrochloride; bottles contained 25 ml of 10% ethyl alcohol in water. Determinations were made by a colorimetric measurement of reaction between formaldehyde hydrozone and potassium ferricyanide.

Thomas, et al[39] found that the autometer could be modified to measure ethyl mercaptan, thiophenol, thiophene and organic chlorine compounds. The reaction basically is oxidation by heat to sulfur dioxide, which is then measured.

Stanford Research Institute collected samples by means of freeze-out traps using dry ice and liquid nitrogen to catch condensable organics.[53] Organic materials remaining on the wall of the freeze-out train were determined by evaporating an ether extract of those substances. The more volatile hydrocarbons were probably not trapped by this method.

Los Angeles County Air Pollution Control District[54] reports the use of infrared spectrophotometer analysis for the detection of oxygenated hydrocarbons. Samples are collected in a freeze-out train with progressively colder solutions. Another method using a combustion train has been developed by the staff of the district for the measurement of total hydrocarbons. A large gas cell with rock salt windows has been developed so that more of the air sample may be used in the infrared spectrophotometer. Concentrations of 0.1 PPM hydrocarbons have been determined.

An activated carbon collecting unit has been described by McCabe.[55] The unit is available for sampling petroleum and hydrocarbon vapors, odors, and aromatics. Dual perforated, activated carbon counters are connected with an air blower. Forty cfm can be passed through a uniformly dense 0.7-inch layer of 6-14 mesh granular activated carbon at a velocity of 25 feet per minute. The efficiency of the unit is not established.

Street air containing carbonaceous gases emitted from motor exhausts might be studied by a method offered by Hirsch.[56] The carbon dioxide content is first determined, then the sample is passed through red hot copper oxide and burned. The increase in carbon dioxide corresponds to the carbon of those carbonaceous gases not completely oxidized.

Summary Discussion of Inorganic Gas and Organic Materials Sampling: For outdoor air sampling reliance is placed on aspiration or displacement devices to capture, and on a variety of solutions specific for retaining the gas desired for analysis. Little has been done to improve or simplify absorption train collection for gases occurring infrequently. Sulfur dioxide measurement has been so essential to assessment of atmospheric pollution in air that investigators have concentrated on instrumentation that is capable of measuring minor concentrations speedily and of providing a timed record of variations that may be used in conjunction with other data and correlated with meteorological information. It is apparent that not all sampling equipment satisfactory in the appraisal of workroom air may be used to detect air pollutants in the lower concentrations found in outside air. Modifications of the original Thomas and Smith-Friis collecting trains are used by most investigators in the country for sulfur dioxide sampling. The autometer, for many years, and the titrilog, more recently, have provided a completely automatic recording method for measuring sulfur dioxide and the complement of acid forming soluble gases. The volumetric method is still standard in England. Each of these has great dependability. We can hope that investigators will turn attention toward improvements in sampling other gases that will approach these in accuracy and utility.

The Present Status

THE authors have attempted in these few pages to select those references among the many that would best trace the evaluation and development of sampling instrumentation and methods.

We could not hope to discuss each and every variation that appears in the handling of some particular sampling program. Major trends are reasonably clear and these give cause for both commendation and criticism.

The principle of thermal precipitation first noted by Aitken in 1870 still has a place in modern air sampling procedure. The means by which the analysis of collected material can be made more easily and accurately have been developed with time and technical tools.

Owens in the course of his research has contributed the jet and the smoke filter as basic instruments for collecting particulate matter. These, too, have been modified, improved and adapted to perform many feats not actually considered by Owens at the time of development. The impinger principle built into practical sampling apparatus by Greenburg and Smith has been used and continues to be used as a basic means of air sample collection.

The electrostatic precipitator has made possible the collection of less than micron size particles with a high degree of efficiency.

The impactor principle has been developed and modified by Sonkin, Wells and others to provide not only collection of particles, but also a size segregation of particles.

Filters of paper, wool, glass, and other materials have been developed to retain wanted materials with minimal resistance to air flow. Addition of indicators and reaction chemicals has made filters a valued adjunct of sampling apparatus.

Thomas, starting with a basic idea for measuring sulfur dioxide, has developed an automatic instrument which is today, with its possible modifications, one of the basic collecting and measuring instruments used for many gases and both organic and inorganic materials. Absorption trains with appropriate scrubbing or absorption solutions are invariably used with some means of impingement or displacement for preparing gas samples for analysis. These trains frequently become complex combinations of bottles, tubes, stopcocks and tubing that rival the unscientific designs of Rube Goldberg. Progress in the simplification of suitable devices for collection of gases other than sulfur dioxide has been notably slow. Investigators are struggling with problems introduced by the need for measuring

minute air-borne concentrations that heretofore have seemed of little or no importance.

Brown and Schrenk[57] in 1942 set forth an excellent group of requirements for methods of atmospheric sampling and analyses. They are worth repeating. A method, to be fully successful, should: (1) be direct; (2) include an efficient sampling procedure; (3) use a sample that requires little or no treatment before the determination is made; (4) employ a determining procedure with a high and known accuracy and precision; (5) be dependable, versatile, simple, rapid, and inexpensive; (6) require only readily available equipment.

To these we add the following for outdoor air sampling. The method should: (7) be capable of adaptation to conditions introduced by meteorological and aerodynamic features not found in work room atmosphere; (8) require reasonably compact, easily assembled units with a minimum of breakable parts.

Few, if any, of the methods of today meet all of these criteria, but some such as the autometer, or the Hemeon smoke filter approach the standards when boundaries for use are established and accepted.

The need for sampling methods and instruments that do meet these criteria is such that research is challenged to produce. A number of newer approaches are in development. Collection by freeze-out trains and combustion trains, the use of spectrographic analysis, the use of optical systems, the adaptation of transmission equipment, the expansion of photographic techniques, the study of sample collection at above ground levels, the investigation of methods for capturing an undisturbed air sample, constitute a partial list of investigations in progress or contemplated in research programs.

Can such technological progress eventually reduce the man-hours required for the collection and analysis of air samples? Can the total cost of air sampling, including instruments and laboratory equipment, be reduced materially? If it can, there should be even greater progress in the solution of air pollution problems than has been witnessed in the past 10 years. Not only will there be an increased interest in the preservation of a reasonably clean air, but there will also be an orderly conservation of air cleanliness that will be acceptable to both industry and public. Controlled positive utilization of the air for safe disposal of air-borne wastes depends on the validity and accuracy of scientific air sampling and sound predictions of waste dispersal.

Bibliography

1. Cohen, J. B.: A Method for Estimating the Weight of Solid Matter in Air. *J. Soc. Chem. Ind.*, 16:411 1897.

2. Des Voeux, H. A., and Owens, J. C.: The Soot-fall of London, Its Amount, Quality and Effects. *Lancet*, p. 47 (January 6) 1912.

3. Kershaw, J. B.: Methods for Investigating and Reading Atmospheric Impurities, Including the Soot and Dust Suspended in the Atmosphere. *Met & Chem Eng.*, 11:339, 1913.

4. Mitchell, J. P.: The Determination of the Dust-fall in the Neighborhood of Cement Plants. *Ind. & Eng. Chem.*, 6:454 (June) 1914.

5. Committee Report: Smoke Abatement and Electrification of Railway Terminals in Chicago. Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals, 1915.

6. Hill, E. V.: Quantitative Determination of Air Dust. *Heating and Ventilation*, p. 23 (June) 1917.

7. Committee Report: Report on Observations in the Year ending March 31, 1921. Advisory Committee on Atmospheric Pollution, Meteorological Office, Air Ministry, London.

8. Owens, J. S.: Atmospheric Dust. *J. Soc. Chem. Ind.*, 41:438R (October 31) 1922.

9. Kimball, H. H., and Hand, I. F.: Investigation of the Dust Content of the Atmosphere. *Monthly Weather Review*, 52, 3:133, (March) 1924.

10. Greenburg, L.: Studies on the Industrial Dust Problem, II. A Review of the Methods for Sampling Aerial Dust. *Pub. Health Reports*, 40, 16:767 (April) 1925.

11. Monnett, O., Perrott, G. J., and Clark, H. W.: Smoke Abatement Investigation at Salt Lake City, Utah. *U.S. Bureau of Mines Buletin No.* 254, 1926.

12. Stern, A. C.: The Measurement and Properties of Cinders and Fly Ash. *Combustion*, 4:35 (June-July) 1933.

13. Bloomfield, J. J.: The Size Frequency of Industrial Dusts. *Pub. Health Reports*, 48, 33 (August) 1933.

14. Hazard, W. G., and Drinker, Philip J.: An Atmospheric Dust Recorder. *J. Ind. Hyg. & Tox.*, 16:192, 1934.

15. Coste, J. H.: The Nature of the Dispersals in Town and Country Air. *Trans. Faraday Soc.*, 32:1162, 1936.

16. Davidson, W. F., and Master, W.: Automatic Dust Sampling and Analyzing Instruments for Atmospheric Pollution Surveys. *Monthly Weather Review*, 69, 257 (September) 1941.

17. Dept. Report: Atmospheric Pollution in Leicester—A Scientific Survey. *Dept. of Scientific and Industrial Research (England), Tech. Papers No.* 1, 1945.

18. Dept. Report: The Investigation of Atmospheric Pollution—Observations in the five years ended 31, March, 1944. *Dept. of Scientific and Industrial Research (England) 26th Report*, 1949.

19. Sonkin, L. S.: A Modified Cascade Impactor. *J. Ind. Hyg. & Tox.*, 28:269 (November) 1946.

20. Magill, P. L.: Techniques Employed in the Analysis of Los Angeles Smog. Proceedings of the First National Air Pollution Symposium, 1949.

21. Hemeon, W. C. L.: Instruments for Automatic Air Pollution Measurements. Report 44th Annual Meet-

ing Air Pollution and Smoke Prevention Association of America, 1951.

22. COSTE, J. H. and COURTIER, G. B.: Sulfuric Acid as a Disperse Phase in Town Air. *Trans. Faraday Soc.*, 32:1198, 1936.

23. OWENS, J. S.: The Smoke of Cities. *Inst. Mech. Eng. Proc.*, 134:211, 1936.

24. MADER, P. P., HAMMING, W. J. and BELLIN, A.: Determination of Small Amounts of Sulfuric Acid in Atmosphere. *Anal. Chem.*, 22:9, 1181, (September) 1950.

25. BUMSTED, H. E.; Chairman, et al: Report of Committee on the Standardization of Air Sampling Instruments. American Conference of Governmental Industrial Hygienists, 1950-51.

26. SCHRENK, H. S., ET AL: Air Pollution in Donora, Pennsylvania. *Pub. Health Bulletin No.* 306, 1949.

27. HARKINS, W. D. and SWAIN, R. E.: The Determination of Arsenic and Other Solid Constituents of Smelter Smoke with a Study of the Effects of High Stacks and Large Condensing Flues. *J. Am. Chem. Soc.*, 29:270, 1907.

28. EISENBUD, M., ET AL: Non-Occupational Berylliosis. *J. Ind. Hyg. & Tox.*, 31:5 (September) 1950.

29. STOKINGER, H. E.: Air Pollution and the Particle Size Toxicity, I. *Nucleonics*, 5, 6:50 (December) 1949.

30. BOURNE, H. C. and RUSHIN, W. R.: Atmospheric Pollution in the Vicinity of a Chromate Plant. *Ind. Med.*, 19:568 (December) 1950.

31. DUNN, J. T. and BLOXAM, H. C. L.: The Presence of Lead in the Herbage and Soil of Lands Adjoining Coke Ovens, and the Illness and Poisoning of Stock Feed Thereon. *J. Soc. Chem. Ind.*, 51, 100T (March) 1932.

32. Memorandum: Industrial Fluorosis, A Study of the Hazard to Man and Animals Near Fort William, Scotland. *Med. Research Council Memo No.* 22, 1949.

33. Departmental Report: Test Procedures and Methods in Air Pollution Control. Air Pollution Control District, Los Angeles County, 1950.

34. Item: Tracking Atmospheric Fluoride. Research for Industry (News Bulletin), Stanford Research Institute, 5, 3:1 (March) 1953.

35 BLOOMFIELD, J. J. and ISBELL, H. S.: The Presence of Lead Dust and Fumes in the Air of Streets, Automobile Repair Shops, and Industrial Establishments of Large Cities, *J. Ind. Hyg. & Tox.*, 15:144 (May) 1933.

36. MAGILL, P. L.: Determination Procedures. *Amer. Ind. Hyg. Assn. Quarterly*, 11:55 (March) 1950.

37. HOLMES, J. A., FRANKLIN, E. C. and GOULD, R. A.: Report of the Selby Smelter Commission. *U.S. Bureau of Mines Bulletin* 98, 1915.

38. IVES, J. E., ET AL: Atmospheric Pollution of American Cities of the Years 1931-33. *Pub. Health Bulletin* 224, 1936.

39. THOMAS, ET AL: Automatic Apparatus for Determination of Small Concentrations of Sulfur Dioxide in Air: Application to Hydrogen Sulfide, Mercaptan, and Other Sulfur and Chlorine Compounds. *Anal. Chem.*, 15:287 (April) 1943.

40. GOLDMAN, F. H., ET AL: Ventilation and Atmospheric Pollution, II. Report of Sub-committee on Chemical Methods in Air Analysis. *Amer. J. Pub. Health Year Book*, 1939-40; 92, 1940.

41. PINCUS, S. and STERN, A. C.: A Study of Air Pollution in New York City. *Amer. J. Pub. Health*, 27:231 (April) 1937.

42. THOMAS, M. D.: Precise Automatic Recording Device for Continuous Determination of Carbon Dioxide in Air. *Ind. & Eng. Chem. Anyl. Ed.*, 5:193 (May) 1933.

43. HENDERSON, Y. and HAGGARD, H. W.: Health Hazard from Automobile Exhaust Gas in City Streets, Garages and Repair Shops. *J.A.M.A.*, 81:385 (August 4) 1923.

44. REYNOLDS, W. C.: Notes on London and Suburban Air. *J. Soc. Chem. Ind.*, 168T (March 28) 1930.

45. PERROTT, G. St. J.: Sulfur Dioxide as a Factor in the Smoke Problem of Salt Lake City. *U.S. Bureau of Mines Report No.* 2128, 1920.

46. SWAIN, R. E.: Atmospheric Pollution by Industrial Wastes. Columbia Univ. Press, 1923.

47. THOMAS, M. D. and CROSS, R. J.: Automatic Apparatus for the Determination of Small Concentrations of Sulfur Dioxide in Air. *Ind. & Eng. Chem.*, 20:645 (June) 1928.

48. THOMAS, M. D. and ABERSOLD, J. N.: Automatic Apparatus for the Determination of Small Concentrations of Sulfur Dioxide in Air, II. *Ind & Eng. Chem., Annl. Ed.*, 1:19 (January) 1929.

49. SMITH, R. B. and FRIIS, B. S. T.: Portable Motor Driven Impinger Unit for Determination of Sulfur Dioxide. *J. Ind. Hyg.*, 13, 10:338 (December) 1931.

50. CHAMBERS, F. A., SINGH, A. D. and DEUTCH, I. A.: Atmospheric Pollution in Chicago. City of Chicago, Report, 1937.

51. THOMAS, M. D., IVIE, J. O. and FITT, T. C.: Automatic Apparatus for Determination of Small Concentrations of Sulfur Dioxide in Air: New Countercurrent Absorber for Rapid Recording of Low and High Concentrations. *Anal. Chem.*, 18:838 (June) 1946.

52. WASHBURN, H. W. and AUSTIN, R. R.: Some Instrumentation Problems in the Analysis of the Atmosphere. Proceedings of the First National Air Pollution Symposium, 1949.

53. Inst. Report: Third Interim Report on the Smog Problem in Los Angeles County. Stanford Research Institute, 1950.

54. Dept. Report: 2nd Technical and Administrative Report on Air Pollution Control in Los Angeles County. Air Pollution Control District, Los Angeles County, 1950-51.

55. MCCABE, L. C.: Atmospheric Pollution. *Ind. & Eng. Chem.*, 42:85A (December) 1950.

56. HIRSCH, J. J.: Methods for the Determination of Carbonaceous Waste Bases and Soot in the Air. *State Medicine*, 40, 5, 300 (May) 1932.

57. BROWN, C. E. and SCHRENK, H. H.: Standard Methods for Measuring Extent of Atmospheric Pollution. *U.S. Bur. of Mines Information Circular*, 7210 (May) 1942.

British Occupational Hygiene Society

ON APRIL 27, 1953, The British Occupational Hygiene Society was formally established. The following officers were elected for the forthcoming year: President, THOMAS BEDFORD; Hon. Secretary, PETER ISAAC; Hon. Treasurer, DAVID HICKISH; and President-Elect, PROFESSOR EARL J. KING. An Executive Committee of twelve has also been named. The AMERICAN INDUSTRIAL HYGIENE ASSOCIATION sends congratulations, and wishes the British Occupational Hygiene Society boundless success in its operation.

Contaminant Characteristics Encountered in Local Exhaust Systems

A GRAPHIC PRESENTATION

JAMES R. KAYSE, Dust Control Products
American Air Filter Company, Inc.
Louisville, Kentucky

THIS PAPER and graph are intended to aid anyone encountering a dust control problem to answer two questions, "What am I dealing with?" and "What do I want the collection equipment to do?" Particle size and concentration will answer the former question and required collection efficiency, the latter.

Concentration

THE concentration of an aerosol in an air stream can be stated as the number, volume, mass or other property of particles contained in a unit volume of air. The question of concentration may influence the "effective" size of the particles and the selection of equipment through such factors as pluggage and maintenance of the collector. In the field of dust control, concentration is normally expressed in grains/cu. ft. of gas, where 7,000 grains = 1 lb. There are three ranges of concentration for aerosols. Industrial dusts conveyed through local exhaust systems will range from 0.01 to 100 grains/cu. ft., with 1 to 10 grains/cu. ft. being the more common. In heating and ventilating work, the concentration of solids will be those found in the outside atmosphere and will vary from 0.2 to 10 grains/1,000 cu. ft. For pneumatic conveying, the concentration will range from 50 to 20,000 grains/cu. ft.

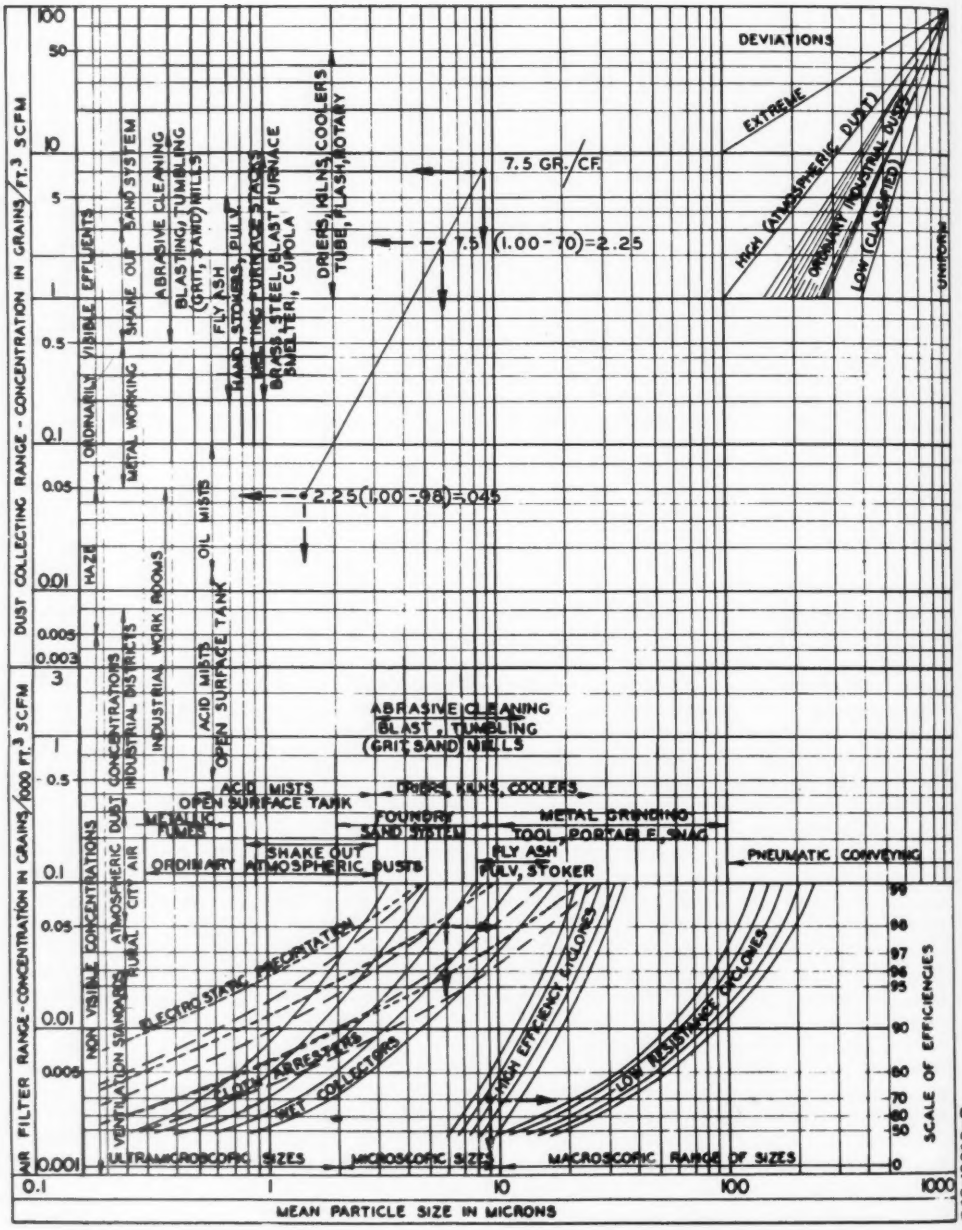
The Sylvan Chart has been divided into two groups: the air filter range with concentrations varying from 0.001 to 3 grains/1,000 SCFM and the dust collecting range with concentrations varying from 0.003 to 100 grains/SCFM. The commonly encountered ranges of concentration for many dust-producing operations are plotted on the chart. For comparative or unknown conditions these data will be sufficient, although variations either exceeding or falling short of the concentrations shown will be found. For applications not illustrated, it will be necessary to select your point on the chart by comparing with an operation that is shown. This comparison can be made on the basis of type of aerosol, method of generation, capture velocity at and location of the hood, and choice of excessive or minimum air volumes. Experience with the operation will also be of great aid in proper selection of concentration. Perfect pin-pointing of the concentration within the range shown for that application is not essential. The accuracy of the chart is such that any minor error made will not greatly affect the end result, which will be an approximation in any event.

Information concerning the concentration of various dust producing sources shown on this chart has been compiled from literature and experience in the field.

Particle Size

MOST dusts are heterogenous, i.e., they are composed of particles of many different sizes. Industrial dusts are originally formed by some means of disintegration and are introduced into the gas stream by an inefficient and more or less random classification process, as in the case of dryer gases or exhaust hoods on shake-out screens. As a result, air-borne dusts generally have

Presented at the Fourteenth Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, Los Angeles, April 23, 1953.



RANGE OF PARTICLE SIZES, CONCENTRATION, & COLLECTOR PERFORMANCE
COMPILED BY S. SYLVAN APRIL 1952 : COPYRIGHT 1952 AMERICAN AIR FILTER CO. INC.

a limiting upper particle size but contain a gradation of particles all the way down to the very finest.

The most common unit of particle size is the micron, defined as 1/1,000 mm. (1/24,500 in.); it is normally designated by the symbol "μ." The average or effective diameter of the particle usually designates the particle size. Another method is the designation of the screen mesh that has an aperture corresponding to the diameter of the particle. Since it is impractical to construct sieves finer than 400 mesh, in dust control work, the particle sizes are usually in the subsieve range. Differentiation between small, medium and large particles is arbitrary. The Manufacturing Chemists Association in their Air Pollution Manual designate fine as less than 10 microns, intermediate from 10 to 50 microns and coarse as greater than 50 microns. On the Sylvan Chart, this differentiation has been shown as ultramicroscopic, microscopic and macroscopic ranging from 0 to 1 micron, 1 to 10 microns and 10 to 1,000 microns, respectively.

The mass mean particle size of aerosols for some of the more common applications is shown on the chart. The mass median represents that size for which the weight of all larger particles is equal to the weight of all smaller particles. Again, deviation from the information presented on the chart will certainly be found but for approximation purposes the particle sizes shown are sufficient. The ranges shown have been compiled from literature and experience. For applications other than those illustrated, follow the same general procedure as indicated previously in the discussion of concentration.

Size Distribution Curve and Deviation

As DUSTS found in practice rarely consist of particles of a given size, to define them one must specify not only the size but also the relative amounts of each size. This is known as particle size distribution. In order to obtain a size and size distribution of a dust, it is necessary to make a particle size analysis. Some of the methods of particle size analysis are sieve, microscopic, elutriation, and sedimentation. Most methods of particle size analysis do not measure particle size but rather measure some other properties which are then converted to an effective particle size by analytical or empirical relationships.

Two methods of plotting particle size distribution are the size frequency curve and the cumulative curve. In the size frequency curve, the number or weight of particles in a given size range is plotted against the average particle size of the range. Rarely is the distribution symmetrical about the preferential size. With dusts it is not uncommon to have two or more preferential sizes in a size frequency curve. In a cumulative curve, the fraction of the total number or weight of particles which have a diameter greater (or less) than a given size is plotted against this size. This curve is more generally used for dusts.

For purposes of presenting, comparing, analyzing or extrapolating particle size analysis in dust control work, logarithmic probability graph paper is convenient. On this paper, particle size is plotted on a logarithmic scale against the cumulative weight percent larger (or smaller) than that size on an integrated probability scale. Plots on this paper frequently give straight lines or lines of relatively small curvature. With this curve, the distribution function can be defined in terms of two parameters, the median size and standard geometric deviation. Standard geometric deviation is expressed as the 84.13% size divided by the 50% size.

An actual distribution curve may contain several intricacies, and it may not be possible to state it mathematically with a finite number of parameters. However by using two independent variables, mean size and deviation, in a mathematical function, it can be shown that (Note 1):

$$\frac{Ci}{Co} = \left(\frac{Di}{Do}\right)^{3+\frac{N}{M}}$$

in which Ci, Co, Di and Do are inlet concentration, outlet concentration, inlet mean particle size and outlet particle size, respectively. The value of the exponent "M" varies for different types of cleaners. For pure impaction, theoretically it should

Note 1: The derivation of the equation can be obtained upon request from Mr. Sylvan.

be between 0.5 and 2. The extremes are never reached in practice and "M" varies no more than between 0.85 and 1.3 for cleaners of the impaction class. In cleaners where diffusion plays an important part, "M" may go down to zero and may even reach negative values. Accordingly, the Sylvan chart is useful for impaction type cleaners only. For these cleaners, the variation in "M" can be neglected without too great an error. The "N" is a dimensionless number depending upon the type of dust and is an arbitrary value depending upon the size frequency curve. The above equation states that when a line is drawn on a logarithmic chart connecting the inlet concentration and inlet mean particle size with the outlet concentration and outlet mean particle size, this line will have a slope of $3 + \frac{M}{N}$.

Visibility of Stack Effluents

RANGE of visible concentrations has been reported as starting at 0.005 grains per cubic foot. This scale refers only to ultramicroscopic particles and cannot be used for most industrial stack effluents. There has been little work done in this field but it is apparent that with coarser particles, much heavier concentrations could be discharged without a visible haze.

Collectors and Collector Efficiency

THIS term refers to the weight ratio of dust collected to that entering. Usually the prime consideration is the concentration of dust in the effluent regardless of inlet concentration. However, neither collection efficiency nor exhaust concentration is in itself a specific characteristic of a given collector. There are many factors involved in selecting dust collectors other than collection efficiency, such as gas properties, dust properties, operating and maintenance considerations, construction and installation factors, and auxiliary equipment.

There are approximately seven different classes of dust collectors: gravity settling chambers, inertial separators, packed towers, fabric arresters, wet scrubbers, electrical precipitators, and miscellaneous including sonic and thermal. For convenience the four major classes have been illustrated on the chart: inertial separators, wet scrubbers, fabric arresters, and electrostatic precipitators.

1. The inertial separators have been divided into two groups: low resistance cyclones and high efficiency centrifugals. The latter includes the mechanical centrifugal collectors.

2. The wet scrubber group includes only those that rely on impingement, diffusion or centrifugal action for their primary means of collecting.

3. The fabric arrester group embraces any collector using fabric media through which the air stream must pass. Actually the media in itself does not separate the dust particles from the air stream because the pores of the media are many times the size of the collected particles. This type of collector relies on the dust particles being impinged on the media and building up a layer which acts as the filter.

4. The electrostatic precipitator group includes both high and low voltage types.

The collection efficiency of these four groups has been plotted against mass mean particle size.

All of the results shown in the graph were found through laboratory and field testing and were not computed mathematically (Note 2). The number of lines shown for each group indicates more than a range for different makes of collectors operating with the same principal. Such variables as specific gravity of the dust, inlet velocity, size of unit, etc., in the centrifugals; water rates, method of scrubbing or impingement, etc., in wet collectors; velocity, type of media, method of vibration, etc., in fabric arresters and velocity, voltage, resistivity of the dust, etc., in electrostatic precipitators determined the different efficiencies.

How to Use the Chart

A SUITABLE collector will be selected for a lime kiln for illustrative purposes of how the chart is used. Referring to the chart, the concentration and mean particle size of the material leaving the kiln will

Note 2: The efficiency η of an air cleaning device can be stated mathematically as $\eta = 1 - e^{-\alpha x}$ in which "x" is a size function of the dust particles and "α" a coefficient depending on the design and operation of the device. The equation was originally derived by Deustch in connection with electrostatic precipitators, but has since been shown to apply to almost any kind of cleaning device.

vary between 3 and 10 grains/cu. ft. and 5 to 10 microns respectively. Assume an inlet concentration of 7.5 grains/cu. ft. and inlet mean particle size of 9 microns. Projection of this point vertically downward to the collection efficiency portion of the chart will indicate that a low resistance cyclone will be less than 50% efficient, a high efficiency centrifugal will be between 60 and 80% efficient, and a wet collector, fabric arrester and electrostatic precipitator will be 97% plus efficient. The latter three collectors are often preceded by a precleaner so a high efficiency centrifugal will be selected. Using the average line of this group, the efficiency will be 70%. Therefore the effluent from this collector will have a concentration of 7.5 (1.00-.70) = 2.25 grains/cu. ft. Draw a line through the initial point with a slope parallel to the lines marked "industrial dust." Where deviation is not known, using the average of this group of lines will normally provide a margin of safety in predicting the mean particle size of the collector effluent. Where this line intersects the line marked 2.25 grains/cu. ft. indicates the mean particle size of the collector effluent. This is 6.0 microns.

A projection of this point of collector effluent vertically downward shows that a second high efficiency centrifugal will be less than 50% efficient. A wet collector, fabric arrester and electrostatic precipitator will be not less than 93% efficient. Selection of an average wet collector will show an efficiency of 98%. The effluent leaving this collector will have a concentration of 2.25 (1.00-.98) = .045 grains/cu. ft. Using the line initially drawn, at the point where it intersects the line of .045 grains/cu. ft. will indicate a mean particle size in the effluent of 1.6 microns.

This chart enables anyone encountering a dust control problem to select two important variables, concentration and mean particle size. By knowing these conditions and the amount of collection efficiency needed, the necessary collector or collectors can be selected so that one can closely predict the concentration and mean particle size of the material going to the atmosphere.

Instrumentation in Industrial Hygiene

THE SCHOOL of Public Health and the Institute of Industrial Health, University of Michigan, have now well under way elaborate plans for an In-Service Training Course during the week of February 15, 1954, at Ann Arbor, on "Instrumentation in Industrial Hygiene," with a Symposium and Clinic, and an extensive exhibit of the scientific instruments used in all phases of industrial hygiene. These plans have been evolved to fill a growing need. The number of instruments used in sampling, measuring and evaluating environmental exposures has increased rapidly during the last few years, and with the increase in number, there has been a corresponding refinement in complexity and specificity of application. No one place exists where information on all of these instruments can be obtained—not even a catalogue; and such information as is available is often more adapted to sales than to science. The School and the Institute at Ann Arbor intend to bring them all together, at one time and place, for the purpose of their scientific study and demonstration. The Symposium and Clinic will be directed to the specific uses of all of the techniques and means of instrumentation, the scientific principles on which they are based, and their applicability to the specific situations for which they are designed. The exhibits will be entirely free from any sales or commercial significance. Underlying the whole project is the desire of the School and the Institute to offer the latest and best scientific answers to the needs of workers in the fields of industrial hygiene as these needs are identified by the workers themselves.

American Industrial Hygiene Association

— FOURTEENTH ANNUAL MEETING —
Los Angeles, California

THE FOURTEENTH Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION was held at the Statler Hotel, Los Angeles, California, April 20-23, 1953. There were 278 members registered for the meeting. The Industrial Health Conference as a whole reported a total registration of 1397 including 130 guests.

Four field trips were arranged and many sightseeing tours and studio trips were also available to the registrants.

As in past years, AIHA held a joint meeting with the American Conference of Governmental Industrial Hygienists on Tuesday, April 21, and a joint meeting with the Industrial Medical Association on Wednesday, April 22.

The concurrent sessions which were originated at the Cincinnati meeting were again favorably received. The divisions sponsoring concurrent sessions were: Air Pollution; Engineering; Toxicology; Chemical and Analytical; and Radiation. A total of 56 papers were presented at AIHA sessions.

The annual banquet was held in the Golden State Room of the Statler Hotel. WARREN A. COOK delivered the Donald E. Cummings Memorial Lecture and accepted the Cummings Award from President WILLIAM R. BRADLEY.

The business meeting was held April 22. President BRADLEY introduced the new officers and directors: President, HENRY F. SMYTH JR., Ph.D., Mellon Institute; President-Elect, HERBERT T. WALWORTH, Lumbermens Mutual Casualty Company. New members of the Board of Directors are ROBERT E. ECKARDT, M.D., Esso Laboratories, Standard Oil Development Company; KENNETH W. NELSON, American Smelting and Refining Company, and H. E. STOKINGER, Ph.D., U.S. Public Health Service.

Certain changes in the by-laws of AIHA were proposed at the business meeting. One of the changes relaxes the requirements for holding office in Local Sections. Under the new proposal, only the Past-President, President, and President-Elect of the Local Section are required to hold membership in AIHA. The other changes involve statements of policy. The new by-laws have been submitted to the membership for ballot.

The 1954 Industrial Conference will be held in Chicago in April. Plans are already being made and it is anticipated that the steady growth of AIHA will be reflected in another record attendance.

Left, William R. Bradley presenting the 1953 Cummings Memorial Award to Warren A. Cook. Right, President-Elect, Herbert T. Walworth; President, Henry Field Smyth, Jr.; and retiring President, William R. Bradley.

♦ President's Page

TODAY 10 members are producing the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION QUARTERLY. They are making something in which we all take pride. Wouldn't each one of you, the 780 other members, like to contribute to the job to help justify your pride? It's only a little thought that's wanted, not work nor money.

The AIHA QUARTERLY needs more excellent papers that non-members will want to study. It needs more news of Local Section activities. It needs more subscriptions from Local Section Associate Members. It needs to be put in more libraries to spread the philosophy of industrial hygiene. It needs more non-member subscriptions. It needs more advertising. Help with any one of the needs will be appreciated, but it is the last one I want to emphasize now.

The AMERICAN INDUSTRIAL HYGIENE ASSOCIATION QUARTERLY is our most tangible accomplishment to date. Its beginnings go back to our first year of existence. Despite the financial support authorized by the Board of Directors, the creation and development of the QUARTERLY has always been an uphill struggle for the small number of volunteers who have devoted uncounted hours of thought and labor to the Journal. We are grateful to the Industrial Medicine Publishing Company for help and encouragement during the early years and for advice in present problems. But today the AIHA QUARTERLY is entirely our own. In the past six years we have spent $5600 from our scanty income to pay its deficits, one-third of the dues we have collected from members in this period.

In 1952 production and distribution costs totalled $5500. Advertising paid half of this, subscriptions from members and associates paid one-fourth and subscriptions from non-members one-ninth. The remaining one-sixth was deficit paid from our treasury. Although the deficit was large in proportion to annual income, about one-fourth of dues payments, yet it has been much reduced in ratio since the 1947 to 1951 period when it varied from one-third to three-fifths of the total cost of publication. The improved showing has resulted from more advertising and more non-member subscriptions, both obtained by publishing a better Journal on time.

During this period nourishing the AIHA QUARTERLY with our money was the most useful expenditure we could make. No one begrudges it. We are proud of what it allowed the volunteer editorial staffs to accomplish. But now we have a fine Journal. It ought to pay its way, giving us leeway to devote income to other useful activities being studied by the Development Committee. We don't want a profit but we do want a self-supporting Journal.

In 1952 a subscription cost us $1.74 and we collected $1.00 toward it from each member and subscribing associate. They got a bargain. Let no one think we don't want more $1.00 subscriptions. Each new one makes our pages more attractive to advertisers. It only looks as if we lose money on it. But each non-member subscription at $2.00 gives us a drop of cream to reduce the deficit a little.

Now for the advertising. It isn't something printed to break up the monotony of pages of text. It is the bread and butter of a Journal and of the advertiser too. It already pays half the cost of the AIHA QUARTERLY but if it paid two-thirds or more we could have an even bigger better Journal without a deficit.

To keep our present advertising and to get more we have to convince the advertiser he gets his money's worth. We represent a tremendous buying power for ventilating and protective equipment, books, laboratory items, and the like. We suggest, we specify, we requisition, we buy. But all this money we control is no help to the AIHA QUARTERLY

unless the advertiser knows we do control it and that what we see in the pages of our Journal has some influence on where the money is spent.

I don't suggest you specify or buy what you see advertised. Certainly you must buy what you think is best for the job to be done. But inquire of advertisers, mentioning the QUARTERLY. Let them know their advertising is read. Who knows, maybe inquiries will reveal the item is after all the best and you will buy it. But in any event let the advertiser know you studied and considered his product. And ask others of your suppliers why you haven't found their advertisements in our pages. In the long run every serious letter of inquiry to an advertiser mentioning your QUARTERLY is worth real money to the Journal.

A little attention to this point will soon erase the deficit. I am not asking for work. Just remember the AIHA QUARTERLY is your Journal and you want to help make it better and relieve yourself from contributing toward a sizeable deficit every three months.

Now, for permanent record, a thumb-nail history of the AIHA QUARTERLY, never before printed, seems appropriate.

1940: The INDUSTRIAL HYGIENE SECTION, official publication of AIHA, appeared in the January, April, July and October issues of INDUSTRIAL MEDICINE. It was paged separately from the journal, numbered consecutively through the year and was bound only in copies, sent to AIHA members. Seventy-two pages of text, 8 by 11 inches in size were published. The Editorial Committtee consisted of C. O. SAPPINGTON, W. A. COOK and W. G. FREDRICK. Volume 1, Number 1 printed a list of the 160 charter members of AIHA.

1941: W. A. COOK was named Editor with Volume 2, Number 4. Sixty-six pages of text were published.

1942: Volume 3, Number 2 and all later issues through Volume 7, Number 1 were bound in all copies of *Industrial Medicine*, hence papers published therein are to be found in library collections of that journal. Eighty pages were published.

1943 to 1945: Volume 4 contained 60 pages, Volume 5 had 68 pages, and Volume 6 had 64 pages.

1946: Volume 7, Number 2 was the first issue as a separate journal with the name AMERICAN INDUSTRIAL ASSOCIATION QUARTERLY and a 7 by 10 inch page size. This and all later issues are still available as back numbers but the stocks are dwindling. Number 4 was notable for a 24-page bibliography on respiratory protective devices by LESLIE SILVERMAN. Volume 7 consisted of 23 large and 95 small pages of text with five pages of advertising. Through this volume the entire cost to AIHA was one dollar per member per year, the subscription price included in annual dues. All deficits were absorbed by Industrial Medicine Publishing Company.

1947: Volume 8, Number 3 was delayed eight months by a printing strike and the AIHA QUARTERLY did not appear on time for two years thereafter. This made it nearly impossible to secure outstanding manuscripts, increased subscriptions or advertising. The AIHA treasury paid half of the deficit. Through this volume the copyright was the property of Industrial Medicine Publishing Company.

1948: Volume 8 contained 93 pages of text and 14 of advertising. During the year AIHA took over all rights in the publication and paid all of the current deficit in addition to a supervision charge of 10% of the gross cost of production and distribution. Industrial Medicine Publishing Company wrote off all its losses with no obligation upon AIHA to reimburse it.

1949: Volume 10, Number 4 appeared on time. The volume contained 96 pages of text and 12 advertising.

1950: Volume 11, Number 1 contained 92 pages of text from the University of Michigan Air Pollution Institute. An intensive campaign doubled the income from subscriptions during the year. With Number 2, H. J. WEBER was named Editor. The volume contained 218 pages of text and 13 of advertising.

1951: With Volume 12 the publisher's supervision charge was increased to 20% of the costs. Intensive efforts trebled the advertising income during a two-year period. The volume contained 167 pages of text and 21 advertising.

1952: With Volume 13, Number 2, H. T. WALWORTH was named Editor. The volume contained 205 pages of text and 43 of advertising and for the first time an annual index in Number 4.

1953: Volume 14, Number 1 appeared with a new professionally designed cover and modernization text lay-out. With Number 2, W. T. MCCORMICK became Editor.

FROM now on further improvement in your journal is up to you. Some can submit outstanding papers and some can obtain more subscriptions. But, everyone can increase the advertising by letting the advertisers know they are getting their money's worth. Write one serious letter to one advertiser for each issue, mentioning the QUARTERLY. Ask one supplier each year why you don't see his advertising in your QUARTERLY. If all of us do these two things, soon we will be offered more advertising than we can print and your QUARTERLY will grow by leaps and bounds.

—HENRY FIELD SMYTH, JR., PH.D.

◆ News of Local Sections

Chicago Section

AT THE MARCH 4, 1953, meeting of the Chicago Section, RUSSELL M. BALL, Chief Engineer, Nuclear Instrument and Chemical Corporation, addressed the group on "Atomic Energy and Safety." MR. BALL made an already enlightening talk even more informative with a question and answer period that he conducted most capably.

On April 1, 1953, the Section met at the Miller Brewing Company in Milwaukee, Wisconsin. The scientific program consisted of the following talks: "Helio-Arc Welding—Problems and Controls," "Clinical Case Report—Symptoms of Delayed Shortness of Breath Following Heavy Ozone Inhalation in Helio-Arc Welding," by DR. E. L. BELKNAP, Globe Union, Inc.; "Industrial Hygiene Aspects of Protected Gas Welding," by DR. W. LEA, Director, Industrial Hygiene Division, Wisconsin State Board of Health; and "Summary of Control Measures for Helio-Arc Welding" by DR. F. A. VAN ATTA, National Safety Council.

MR. JENSEN, Senior District Engineer for Westinghouse Electric Corporation, addressed the Section at its May 6, 1953, meeting. With his "Lighting for Health and Safety," the speaker acquainted an attentive audience with numerous little-known facts concerning Lighting and Illumination. Excellent slides added to the comprehensibility of MR. JENSEN'S difficult subject, but nonetheless, well prepared talk.

Twenty-seven new members were introduced at the meeting. The total membership of the Chicago Section has now reached two hundred and seventy.

Washington-Baltimore Section

THE NAVAL Gun Factory Officers Club in Washington, D.C. was the setting of the May 12, 1953, joint meeting of the Washington-Baltimore Section of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION and Washington members of the American Society of Safety Engineers.

DAVID Z. BECKLER, Assistant Director, Office of Industrial Development, U.S. Atomic Energy Commission, spoke on the subject "Plain Talk on the Peace-Time Atom." JOSEPH E. FLANAGAN, JR., Assistant Chief of the Division of Occupational Health, Public Health Service, reported briefly on the Industrial Health Conference recently held in Los Angeles, California.

Western New York Section

THE WESTERN New York Section met on March 16, 1953, at the University of Rochester School of Medicine and Dentistry, Atomic Energy Facilities. The following officers for the year 1953-54 were installed at the meeting:

President—DR. FRANK A. SMITH, Atomic Energy Project, University of Rochester; President-Elect—HAROLD W. CROUCH, Eastman Kodak Company; Secretary-Treasurer—E. C. RILEY, M.D., Eastman Kodak Company; Executive Director—DR. CHARLES A. SPIEGL, Atomic Energy Project, University of Rochester.

Northern California Section

THE NORTHERN CALIFORNIA Section met at the Bow and Bell Restaurant in Oakland, on March 17, 1953. DR. FRANK R. DUTRA spoke on the general subject of "Dusty Lungs." He explained in layman's terms the various types of pneumoconiosis making a differentiation between those which were actually disabling and those which in general were not considered to be disabling. The talk was augmented by slides which showed various types of pneumoconiosis. DR. DUTRA also discussed microscopic pictures of lung tissue in some detail. The address was enthusiastically received as an interesting and enlightening presentation.

Georgia Section

THE GEORGIA Section met on May 13, at the Georgia Institute of Technology. "The Effect of Sound" was the program for the evening. Panel members with their noteworthy contributions were the following: DR. JOSEPH, E. MOORE, Director, Psychology Department, Georgia School of Technology, "Emotional Effects of Sound"; DR. HARLOW ADES, Professor of Anatomy, Specialist in Sound and Hearing, Emory University Medical School, "Physical Effects of Sound"; RICHARD CARR, Secretary, State Board of Workmen's Compensation, "Legal Effects of Sound"; DR. WALTER MICKLE, Professor of Anatomy, Specialist in Sound and Hearing, Emory University Medical School, "Instruments for the Measurement of Sound"; and DR. SEWARD MILLER, who served as Moderator and gave "Outstanding Programs of Sound."

The Section announces the following officers for the forthcoming year: President—JOHN W. LEMON, Industrial Hygienist, Fulton County Health Department, Atlanta, Georgia; President-Elect—RUDOLPH P. LEWIS, Industrial Hygienist, Division of Industrial Hygiene, Georgia Department of Public Health, Atlanta, Georgia; and Secretary-Treasurer—HUGH PARKER, Director, Division of Industrial Hygiene, Georgia Department of Public Health, Atlanta, Georgia.

Michigan Section

ON MAY 26, The Michigan Section met at Carl's Chop House in Detroit. The following speakers offered brief reports on various papers and subjects which were presented at the Annual Health Conference just held in Los Angeles: DR. O. T. MALLERY, JR., Chairman of the meeting, reported on medical aspects of the conference; D. D. IRISH—Toxicology; FRANK PATTY—Noise; KATHLEEN KUMLER—Chemistry; ESTHER KIMLER—Nursing; VICTOR LAVETTER—Radiation; JACK C. RADCLIFFE—Air Pollution and Engineering. Abstracts of the papers presented at the Los Angeles Conference were also available at the dinner meeting.

Ohio Valley Section

THE OHIO Valley Section has recently completed and mailed to its members and others on the Section's mailing list a membership booklet. In addition to the names of the members, the booklet carries the By-Laws of the Section, the names of its officers and the committee appointments.

Announcements

THE AIHA Personnel Placement Committee has been discontinued and its work is now in the office of the Executive Secretary, HENRY F. SMYTH, JR., Ph.D., Mellon Institute, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.

ON MAY 18, 1953, the Manufacturing Chemists' Association issued a new revised edition of its chemical labeling bible, "Manual L-1: Warning Labels." Copies of the 98-page booklet are available from the Manufacturing Chemists' Association, Inc., 246 Woodward Building, Washington 5, D.C. Price $1.00.

RIGHTS to translate into Japanese and publish the book "Industrial Health Engineering" by ALLEN D. BRANDT, Chief Industrial Hygiene Engineer, Bethlehem Steel Company, have been purchased by the Nohon Anzen Eisei Kyokai Publishing Company. The book treats all aspects of controlling the industrial environment for the comfort and health of the workers and was published in 1947 by John Wiley & Sons, Inc.

THE UNIVERSITY OF MICHIGAN Sixth Annual Conference on Aging will be held in Ann Arbor, July 8-10, 1953. The Conference this year, "Careers for Maturing Workers," will deal with the problems associated with earning in the later years and with methods of creating new opportunities for remunerative activity by aging people.

L. I. SHAW, Ph.D., has recently established his own offices as Engineering Consultant at 1150 Eighteenth Street, Santa Monica, California. DR. SHAW, who immediately preceded HENRY F. SMYTH, JR., Ph.D. as Executive Secretary of the AIHA, will resume his work in Industrial Hygiene Engineering in addition to serving as Consultant for problems pertaining to Special Ceramics, Bodies and Coatings.